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Biological Services Program

FWS/OBS-80/64
September 1980

ORIGINAL

Enhancement of Fish and Wildlife Resources in the Reclamation of Hard Rock Mined Areas in the Upper Midwest

A GUIDELINES MANUAL

Fish and Wildlife Service

U.S. Department of the Interior

847

The Biological Services Program was established within the U.S. Fish and Wildlife Service to supply scientific information and methodologies on key environmental issues that impact fish and wildlife resources and their supporting ecosystems.

Projects have been initiated in the following areas: coal extraction and conversion; power plants; mineral development; water resource analysis, including stream alterations and western water allocation; coastal ecosystems and Outer Continental Shelf development; environmental contaminants; National Wetland Inventory; habitat classification and evaluation; inventory and data management systems; and information management.

The Biological Services Program consists of the Office of Biological Services in Washington, D.C., which is responsible for overall planning and management; National Teams, which provide the Program's central scientific and technical expertise and arrange for development of information and technology by contracting with States, universities, consulting firms, and others; Regional Teams, which provide local expertise and are an important link between the National Teams and the problems at the operating level; and staff at certain Fish and Wildlife Service research facilities, who conduct inhouse research studies.

March 3, 1849

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

EASTERN ENERGY AND LAND USE TEAM
Route 3, Box 44
Kearneysville, West Virginia 25430

Dear Colleague:

The Eastern Energy and Land Use Team, Office of Biological Services, is pleased to provide you with a copy of a recent publication. This product is intended to aid the biologist, planner, manager and public in land/water use decisions affecting the Nation's fish and wildlife resources. The Team documents may be in the form of reports, manuals, handbooks, guidance documents, and workshop and symposium proceedings that summarize existing information on fish and wildlife and their habitats. These tools make possible sound decisions concerning protection and enhancement of our valuable fish and wildlife resources.

The information provided in this and other Team publications are tuned to particular current issue areas, e.g., coal and mineral development activities on a broad regional basis, water resources development activities on a nationwide basis, and ecological characterizations of faunal assemblages to assist in classification and inventory of fish and wildlife and their habitats.

We are interested in your thoughts concerning this publication and the kinds of information materials you would like to see the Team produce in the future. We invite you to write us at your convenience.

Sincerely,

Edgar A. Pash

Edgar A. Pash, Team Leader
Eastern Energy & Land Use Team

FWS/OBS-80/64
September, 1980

ENHANCEMENT OF FISH AND WILDLIFE RESOURCES IN THE RECLAMATION OF HARD ROCK MINED LANDS IN THE UPPER MIDWEST

A Guidelines Manual

by

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Performed for

FISH AND WILDLIFE SERVICE
U.S. DEPARTMENT OF THE INTERIOR

PREFACE

In the upper midwestern states of Michigan, Minnesota, and Wisconsin, as in most of the United States, the amount of land available for fish and wildlife habitat has been steadily decreasing. This shrinkage is the result of increasing urban, industrial, and agricultural development. Surface iron mining in particular has removed land from a heavily forested land base that, at one time, functioned as wildlife habitat. This manual focuses on methods of returning lands disturbed by current hardrock mining to a condition suitable for integration of the needs of wildlife with other land uses.

The key to the establishment of quality wildlife habitat is a diversity of plant cover. Consequently, the barren ground produced by open-pit mining needs plant life before wildlife will begin to innabit it. In Upper Midwest mining areas, this revegetation process ordinarily will not be impeded by insurmountable problems.

Most mining wastes produced by current surface mining in the Upper Midwest are essentially not toxic or acidic. For the most part, these wastes are the result of iron ore and taconite mining. Surface overburdens can support plant life without special treatments, and taconite tailing can be augmented to promote the growth of vegetation. Exhausted mine pits and water reservoirs are excellent water sources. These resources, in combination, provide the basic elements necessary for successful reclamation. With proper reclamation planning, these abandoned minelands could eventually blend into the surrounding natural landscape to provide various commodities, fish and wildlife habitat, and recreational areas.

The information included in this manual is the result of an extensive research effort, the goal of which was to identify the "state of the art" in current mineland reclamation practices in the Upper Midwest, with particular emphasis on the development of fish and wildlife habitat. This effort included an exhaustive literature search as well as contact with people in the mining industry who have had first-hand experience with the difficulties of reclamation in general and with efforts in behalf of fish and wildlife in particular.

The manual is designed specifically to encourage inclusion of wildlife habitat enhancement considerations in the reclamation planning process. The manual is not intended as a comprehensive guide to specific techniques of mineland reclamation. Instead, it discusses in general the concept of reclamation planning, the environmental factors that affect any revegetation effort, and the reclamation options most likely in today's Upper Midwest mining areas within the context of fish and wildlife habitat enhancement. The term, "enhancement," as it is used in this manual, refers to development of a set of site conditions that optimizes the potential for wildlife development on minelands that are being reclaimed primarily for other purposes, such as forestry or agriculture. For example, on a site to be reclaimed for commercial forestry, enhancement of that site for wildlife would involve designing a site that would benefit wildlife to the extent possible without hampering commercial forestry practices.

The manual's intended audience is the people who carry the burden of responsibility for designing and implementing the reclamation plans of the future. Because these people vary in their levels of expertise, the manual is organized for access at any point. The reader who is relatively new to the fields of mineland reclamation and wildlife management will probably want to read the manual from cover to cover. Those with more experience may choose to focus their attention on the specific section or appendix most important to them.

Field reclamation specialists face what must sometimes seem to them an impossible challenge--transforming post-mining landscapes into productive areas, while spending as little as possible, and while fulfilling the myriad requirements of the myriad regulatory agencies. With these people in mind, the authors strove to create an easy-to-use document that would focus attention on reclaimed minelands as potential fish and wildlife habitats.

Though this manual has been structured for easy understanding of the elements of reclamation, it should not be assumed that reclamation is a standardized, step-by-step process. On the contrary, each reclamation effort has a personality of its own depending on the nature of the site to be reclaimed. In this manual, the authors have attempted to provide working information about the important aspects of reclamation; however, the field is still very young. Consequently, the literature search uncovered very little specific information about reclamation of metallic mineral mining areas. Therefore, though it was intended as a guide to fish and wildlife enhancement for the reclamation specialist, this manual is not comprehensive.

At times the reader will find it necessary to consult other more detailed literature sources for answers to specific problems (a list of references has been provided for that purpose at the end of each section). At other times, an expert in a certain field may have to be consulted (Appendixes A and B are lists of public and private consulting sources). There will also be times when answers are not available from any source, and the reclamation specialist will have to develop his own answers by trial and error. If, however, this manual helps its users simplify their tasks while making the needs of fish and wildlife conscious considerations in the reclamation process, it will have accomplished its purpose.

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ACKNOWLEDGMENTS

Like any book whose purpose is to instruct, this guidelines manual is a compilation of knowledge that originated not only with the authors, but with the countless other men and women who have pioneered mineland reclamation and fish and wildlife management practices throughout this country and throughout the Upper Midwest. Though it would be impossible to acknowledge the contributions of everyone who assisted us in the manual's development, we would like to thank those whose ideas helped to make the final product a more usable tool than our early drafts.

We are especially indebted to the representatives of the mining companies and government agencies who gave so freely of their time and experience in helping us to improve this resource. Suggestions made by the people who attended our workshop in Duluth on July 10, 1980, contributed immeasurably to the effort.

In particular, we are indebted to the Copper Range Company of White Pine, Michigan, and Erie Mining Company of Hoyt Lakes, Minnesota. Their successes in mineland reclamation and wildlife management and their suggestions during the course of this project provided much of the basis for the recommendations and helpful aids contained herein.

Though many people helped with the development of this manual, the authors alone are responsible for any errors or shortcomings it may contain.

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HOW TO USE THIS MANUAL

In some ways, reclamation in today's world is more an art than a science. The field is constantly changing and growing, ensuring that the related body of knowledge is dynamic. In addition, each specific site destined for reclamation offers its own peculiar challenges and quirks, thus sometimes requiring innovative approaches to solving particularly thorny problems. Because of this dynamic and site-specific nature, reclamation planning and implementation is extremely difficult even under the best of circumstances. This makes it impossible for even the most exhaustive literature resource to lead the reclamation specialist through the reclamation process without some difficulties.

With these limitations in mind, the reclamation specialist should marshall every resource at his disposal to help him with the development and implementation of his reclamation plan. This guidelines manual is one of those resources, and it will be useful in helping its user identify other more specific resources.

In general, this manual presents basic information about the planning and implementation of reclamation efforts. In each section, a particular topic is discussed in general, and other sources of more specific information are provided. The appendixes provide lists of consultants, laboratories, nurseries, government agencies, and literature references as well as information about wildlife species, fish, and plants.

The introductory sections (Introduction to Reclamation Planning and Summary of Environmental Factors) provide background that the reclamation specialist who is new to the field might need as well as some information that will be helpful to more experienced people. The Introduction to Reclamation Planning discusses how the planning process generally works and some of the constraints that will have to be considered in the development of the reclamation plan. The Summary of Environmental Factors discusses the problems generally associated with the physical nature of mining sites destined for reclamation. The discussion highlights those factors which are most directly responsible for success or failure of revegetation efforts.

The four sections devoted to specific reclamation options (forestry, agriculture, wildlife, and fisheries) present a general picture of the state of the art in reclamation practices involving revegetation and fish and wildlife. The forestry section emphasizes commercial forestry practices and discusses techniques for the integration of the needs of wildlife with logging operations. The agriculture section discusses the most likely agriculture land uses in Upper Midwest mining areas (hay production and pasture for grazing) and also presents ideas for the integration of wildlife. The wildlife section shows how minelands can be reclaimed exclusively as wildlife habitat. The fisheries section explains how fisheries might be developed in mining areas; however, to date, systematic studies of the potential for fisheries development on minelands have not been conducted.

The worksheet section provides a tool for the manual's user to evaluate his site and reclamation plan with wildlife habitat in mind.

As discussed previously, the appendixes provide much specific information on individuals, organizations, and literature sources that will help the manual's user find answers to specific questions.

In short, this manual is a tool, to be used in conjuction with the other tools available to the reclamation specialist. It can be used as an introduction to the field for the newcomer and a basic guide and reference work for others. In those capacities, the authors hope the manual will save its users needless headaches and wasted time and money.

INTRODUCTION TO RECLAMATION PLANNING

For the purposes of this manual, "reclamation" is the process of returning an area disturbed by mining to its former state or to a state suitable for equivalent or superior use and benefit. In Upper Midwest mining areas, reclamation could take many forms. Depending on what surrounds the mining sites and other factors, the area might be reclaimed for urban or industrial development, residential or recreational areas, forest crops, hayfields or pastures, fisheries, wildlife areas, or varying combinations of all of these.

RECLAMATION OPTIONS

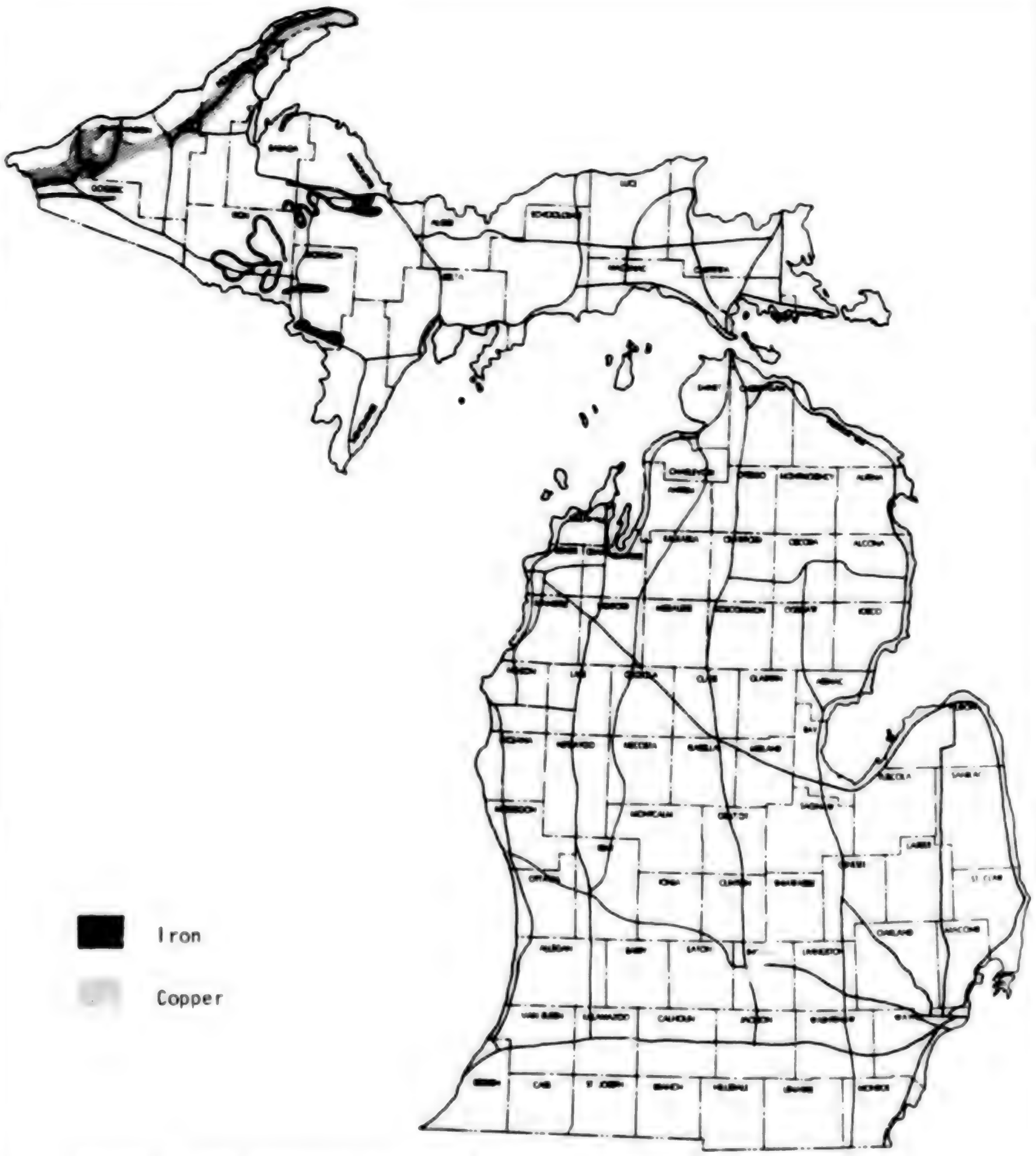
In the development of this manual, preliminary consideration was given to all of the reclamation options mentioned above; however, only four of them offer potential for fish and wildlife habitat. Of course, reclamation specifically for wildlife areas and fisheries are two of them. The other two options are forestry and agriculture.

Figures 1, 2, and 3 show most of the potential metallic mineral areas in Michigan, Minnesota, and Wisconsin. These areas are not static however. As exploration continues, more areas are discovered. Consequently, the maps presented here can only provide an incomplete picture.

Because most of the current mining in these three states is limited to their northern portions, most of the land surrounding the mining areas is heavily forested. These forests function as wildlife habitat and, in some areas, produce forest crops. Consequently, much of the reclamation activity in the region will center on forestry and wildlife.

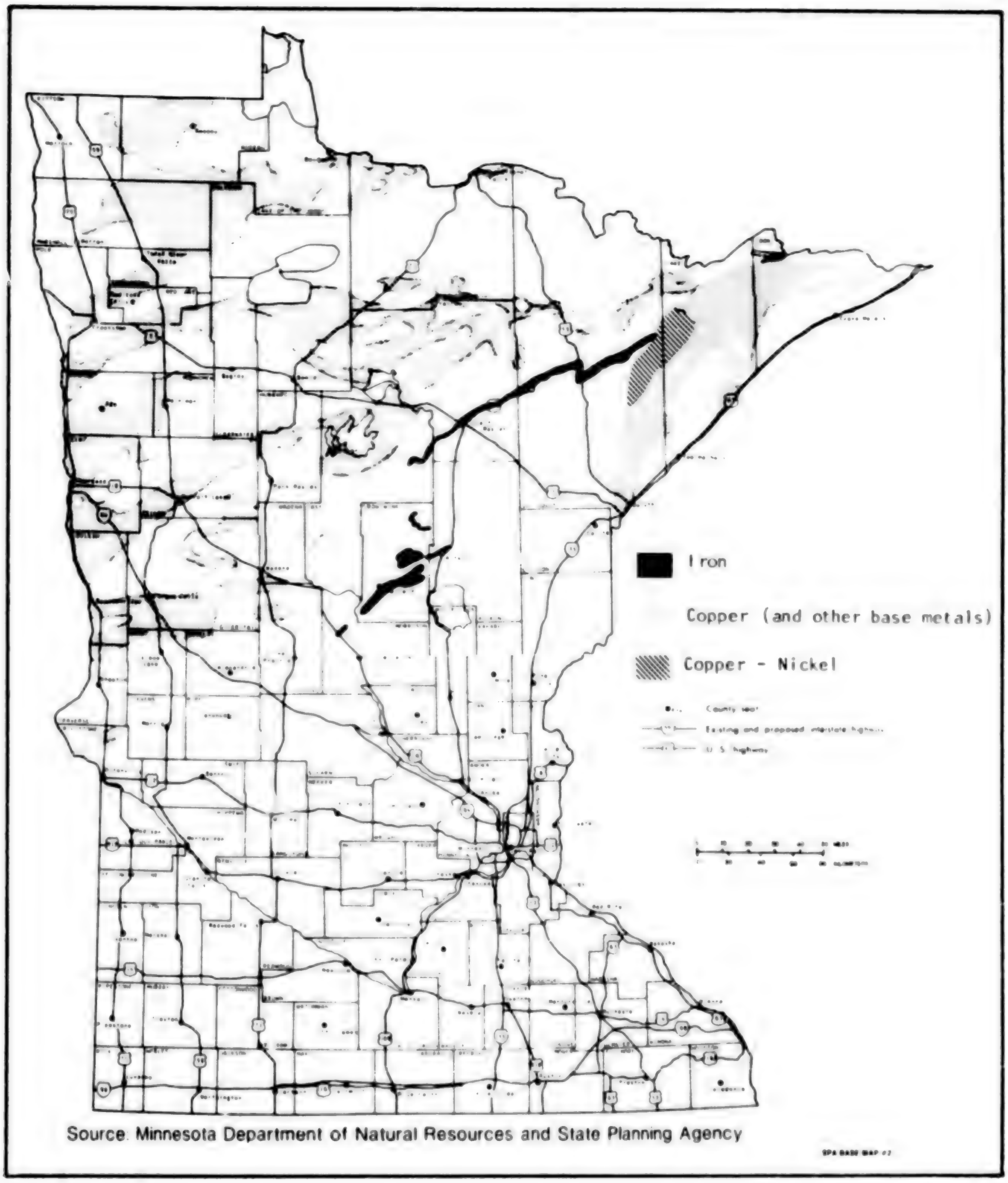
Because of the unsuitable climate and relatively poor soil conditions in the region, agriculture is a very limited land use. The cultivation of row crops and orchards is generally not possible except in rare instances. Pastures and hayfields, however, could be practical reclamation options under the right conditions.

The development of fisheries in abandoned mine pits and tailing basins is not yet a practical reclamation option, though it has great potential for the future. Currently, mining practice produces mines that are very large and very deep with very steep slopes and virtually sterile substrate conditions. These conditions combine to make fisheries development on abandoned minelands economically impractical in most cases. It is possible that future government regulations may require increased in-mine waste disposal, resulting in substantially shallower mine pits, which in turn would make fisheries development more practical.



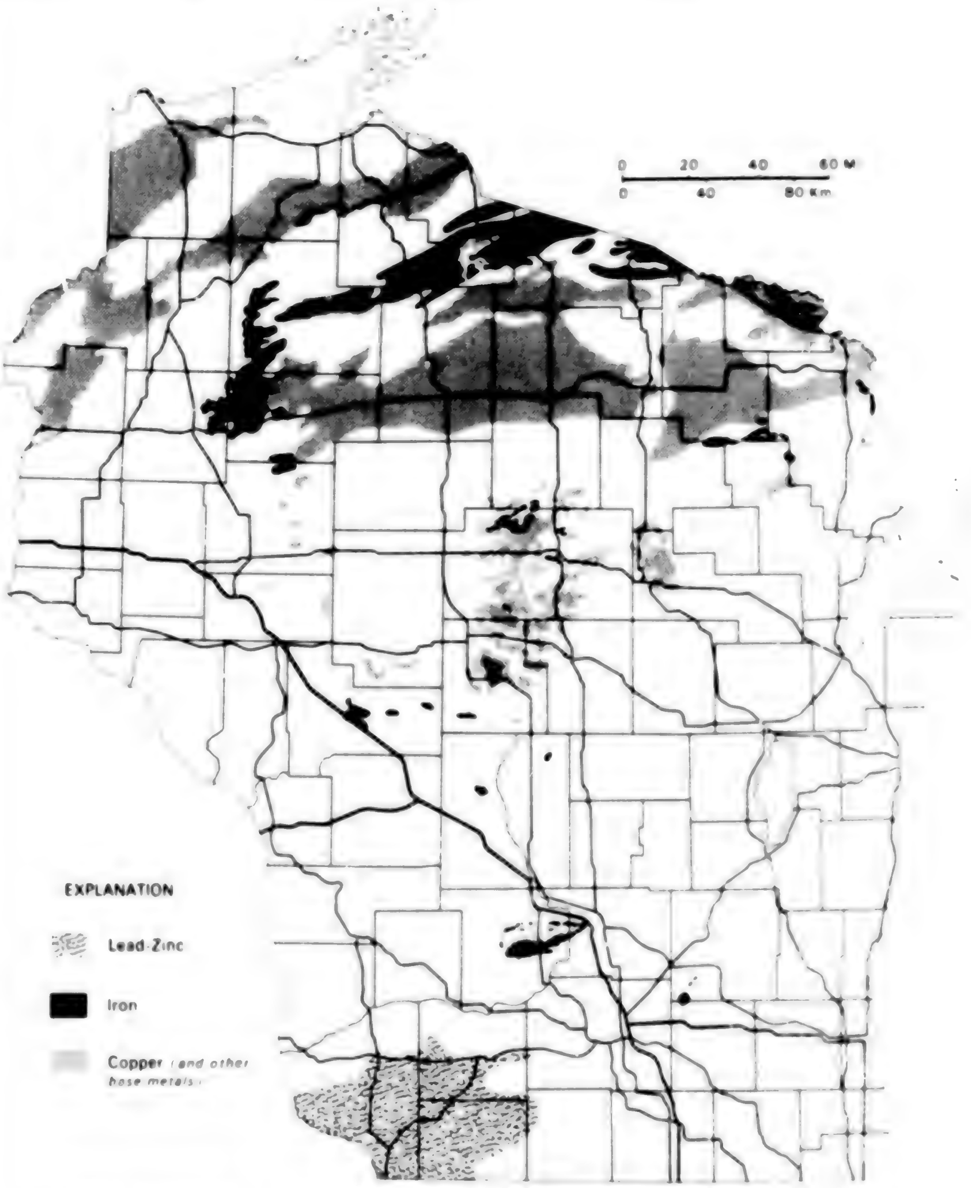
Source: Michigan Department of Natural Resources, Geological Survey Division

Figure 1. Pote[illegible] metallic mineral areas in Michigan.


Iron
Copper (and other base metals)
Copper - Nickel
County seat
Existing and proposed interstate highway
U. S. highway

Source: Minnesota Department of Natural Resources and State Planning Agency

Figure 2. Potential metallic mineral areas in Minnesota.



Source: University of Wisconsin-Geological and Natural History Survey

Figure 3. Potential metallic mineral areas in Wisconsin.

CONSTRAINTS ON RECLAMATION ACTIVITIES

The physical characteristics of the mine site present one set of limitations to be overcome if reclamation efforts are to be successful. Equally important considerations are the limitations imposed by government agencies, the nature of the area surrounding the site to be reclaimed, the costs associated with reclamation, and the concerns of the people who live in the area. This section discusses the general considerations associated with each of these constraints.

Current Government Regulations*

Government regulations affect virtually every aspect of mining operations. Some of these regulations are directly related to mining, but many govern environmental elements that may be only peripherally affected by mining practices. Because regulations govern many different areas and are administered by many different agencies, it is impractical to discuss them all in this manual. It is important, however, that applicable regulations be considered before preparation of the reclamation plan. Therefore, the reclamation specialist should make a point of contacting the appropriate government agencies for information about the regulations that may affect a particular site.

This section compares current and proposed laws and regulations that are directly related to mining operations in Michigan, Minnesota, and Wisconsin to the requirements of the Surface Mining Control and Reclamation Act of 1977. Because of the constantly-changing nature of these laws and regulations, it is not practical to discuss them in detail. Consequently, this discussion focuses on just the important aspects of each state's regulations.

In general, the state frameworks provide for submission of reclamation plans by mine operators in the context of applications for permits to mine and for a review of these plans by state administrative agencies. After administrative review, permits are granted. The primary areas considered are land use after reclamation; regrading of waste areas; and avoidance of water pollution, erosion, and air pollution. In each state, the administrator has considerable discretion in terms of the technical specifications required prior to approval of a plan. Details of the state programs differ as described below.

Michigan. Michigan law requires anyone proposing to engage in surface mining to submit to the Geological Survey Division of the Department of Natural Resources a notice and a yearly plan accompanied by a report of reclamation activities undertaken and proposed. The supervisor of the Geological Survey Division may also require the operator to submit a long-range, detailed reclamation plan. Reclamation activities are subject to regulatory requirements promulgated by the Geological Survey Division. Failure to submit a plan can lead to injunctive action by the State Attorney General.

---

*Most of this section was derived from the Draft Report of the Panel on Large Open Pit Mines in Humid Environments which was commissioned by the National Research Council Committee on Surface Mining and Reclamation, 1979.

The Michigan reclamation regulations contain only generalized criteria. The plan requirements and the plan map must contain a detailed description of the mining area, the reclamation problems involved, the operator's plan to achieve short-term and long-term reclamation, an estimate of the time schedule for the completion of the reclamation, and the estimated cost of reclamation. Upon submission of the plan, and prior to approval, mining may proceed. (See Michigan Comp. Law Ann. Section 425.181 et seq.; Mich. Admin. Code R 425.1-425.49.)

Minnesota. The Minnesota Mine and Reclamation law requires submission of a permit application including a reclamation plan and map prior to mining. The regulations were patterned to some extent from the Surface Mining Control and Reclamation Act. They are substantially more detailed in their requirements than Michigan's or Wisconsin's regulations, and include specifications for slopes, type, percentage of revegetation, and types of technology to control particular problems. (See Minnesota Stat. Section 93.44-93.51, Minnesota Reg. NR 401-411.)

Minnesota has a procedure for determination of areas unsuitable for mining, and noise from blasting is regulated. Civil penalties are provided for, and the Commissioner of Natural Resources has emergency authority to suspend operations where there is imminent danger.

Wisconsin. Wisconsin has a mining permit program and a procedure for identification of areas unsuitable for mining. Before obtaining the permit, the mine operator must submit a reclamation plan to the Department of Natural Resources for approval. The program currently operates under regulations promulgated in 1979; however, these are being revised and will include regulations for mineland reclamation and waste management.

Wisconsin's regulations currently require that the mining plan include:

a. a map of the proposed area;

b. details of the nature and extent of the final mining excavation;

c. details of operating procedures including mining sequence and tailing productions, ore processing, plans for water management and treatment, plans for air quality protection; and

d. indications that the mining operation will comply with minimum standards in the following areas: grading and stabilization, prevention of erosion, stabilization of refuse, avoidance of erosion and contamination, coverage and storage of pollution-bearing materials, removal and stockpiling of topsoils prior to mining, maintenance of adequate vegetation, safe impoundment of water, and screening of the mine site.

The current regulations also call for a detailed reclamation plan. This includes information on the reclamation sequence and any interim reclamation to be undertaken, as well as the planning for long-term maintenance of the site. Minimum standards are established. Topsoils must be removed and stored for reuse. Tunnels and underground openings must be sealed. Water management practices are required to prevent erosion. Disturbed surface areas must be revegetated with indigenous plants as soon as practical. If the mining operation has a long life span, sequential reclamation must be practiced. Again, administrators have great discretion in reviewing the plan. (See Wisconsin Stat. Ann. Section 144.80-144.94, Wisconsin Admin. Code Ch. NR130-132.)

Summary. Because of the continuously changing nature of state regulations governing mining in this region, it is important to contact the appropriate agency for current reclamation requirements. Appendix C lists the regulatory agencies in each state with their addresses and telephone numbers.

Surrounding Land Use

Land use patterns in the vicinity of the mine site are one of the primary factors affecting reclamation efforts. Local zoning regulations often define acceptable land use, and they might not permit reclamation options which would otherwise be attractive.

Perhaps more important is the necessity to ensure that reclamation plans are ecologically and practically compatible with adjacent areas. For example, if the area surrounding a mine site is highly industrialized, agriculture would probably be an unattractive option. Or, as is likely in the Upper Midwest, if the mine site is surrounded by forests, reclamation for forestry and wildlife would probably be the more appropriate choices.

Reclamation Costs

A detailed analysis of the cost factors associated with the various reclamation options is not within the scope of this manual. Further, because choices for reclamation may be severely restricted by other considerations (government regulations, surrounding land use, the physical nature of the site to be reclaimed, etc.), reclamation costs, for all practical purposes, may be fixed.

In thinking about the costs of reclamation, some costs tend to be forgotten or minimized in the planning stage. These are usually the costs associated with meeting specific regulatory requirements or management objectives that have not yet been attempted elsewhere in the industry. For instance, in some cases, original research or much field testing may be necessary to establish a certain plant species in an inhospitable location. Repeated failures on one site may precede any success, thus increasing costs beyond expectations. In particular, because of the pioneering nature of any reclamation effort that focuses on specific types of land management, precedents for estimating costs may not be available. Therefore, the potential for accurate cost predictions may depend on both the peculiarities of the site to be reclaimed and on the specific method of land management to be attempted.

In general, however, any reclamation effort will offer some potential for economizing. The danger, of course, is that a reclamation strategy that might be economical in the short run ultimately could be very expensive. For example, the choice of one planting or seeding technique over another because of its lower initial cost may result in the unforeseen need for additional plantings in following seasons, resulting ultimately in greater expenditures and lost time.

Public Concerns

No reclamation plan can be developed in a vacuum. The people in the area surrounding the mine site who will eventually live with the decisions made by reclamation specialists are a most important consideration. Consequently, their concerns need to be addressed if the plan to be used is to progress smoothly. Bringing the public into the planning process early is probably the most effective means of getting their suggestions and concerns without alienating potential allies. Potential vehicles for public input to the planning process are numerous and can be organized as a part of the mining company's regular public relations program.

THE RECLAMATION PLAN

A well-conceived reclamation plan integrates the various elements of the mining site with each other and with the surrounding area. Possibilities for enhancement of wildlife habitat potential will be coordinated with promotion of the primary land uses, such as agriculture and commercial forestry. Because of the large size of most open-pit mining operations in this region, the use of only one reclamation option is rarely possible. In most cases, the mine operator must assess not only the reclamation potential of the mining site, but also the land around the site, government regulations, cost considerations, wildlife needs, and the public's concerns. The end result may involve implementation of a combination of reclamation options integrated with each other, the surrounding area, and the needs of indigenous wildlife.

Planning reclamation is a systematic process. Ordinarily, the reclamation plan is developed before mining starts and is closely coordinated with the mining plan. The integration of the mining plan with the reclamation plan helps to ensure the effectiveness of reclamation efforts, and it helps to minimize costs; however, many existing mining operations began before reclamation was required. For those operations, integration of the mining plan with reclamation plans is much more difficult.

During the development of the reclamation plan, the proposed mine site is analyzed in detail (e.g., physical environment, government regulations, costs, public concerns) to identify likely problems during and after mining, as well as during reclamation. Based on site analysis, compatible reclamation options can be determined. Once these specific land uses are identified, the details of the reclamation plan can be developed. Figure 4 illustrates the initial steps of a reclamation plan at one active mine site. Figure 5 shows the details of the plan for the same site as it might have been developed later.

One useful procedure in developing a reclamation plan uses a list of the specific problems (e.g., infertility, erosion, visual impact) to be addressed by the plan. Then, the proposed treatment of each problem is listed. These treatments are divided into phases of reclamation; landform design, surface hydrology, soil management, revegetation, etc. The objectives of each reclamation phase can then be easily identified by referring to the problem and proposed treatment. The overall reclamation plan is developed from this worksheet. At a minimum, a reclamation plan should include:

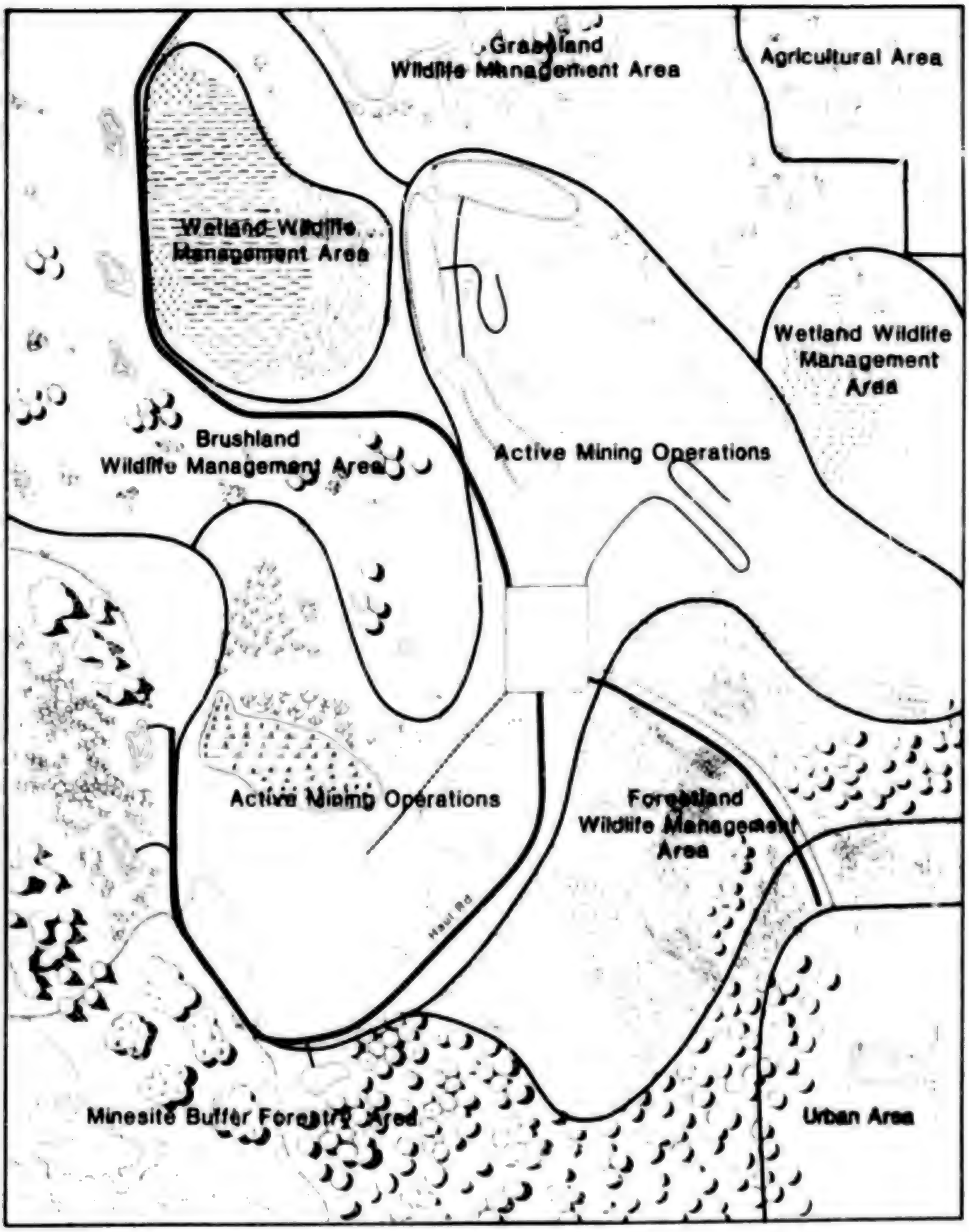


Figure 4. Conceptualized reclamation plan.

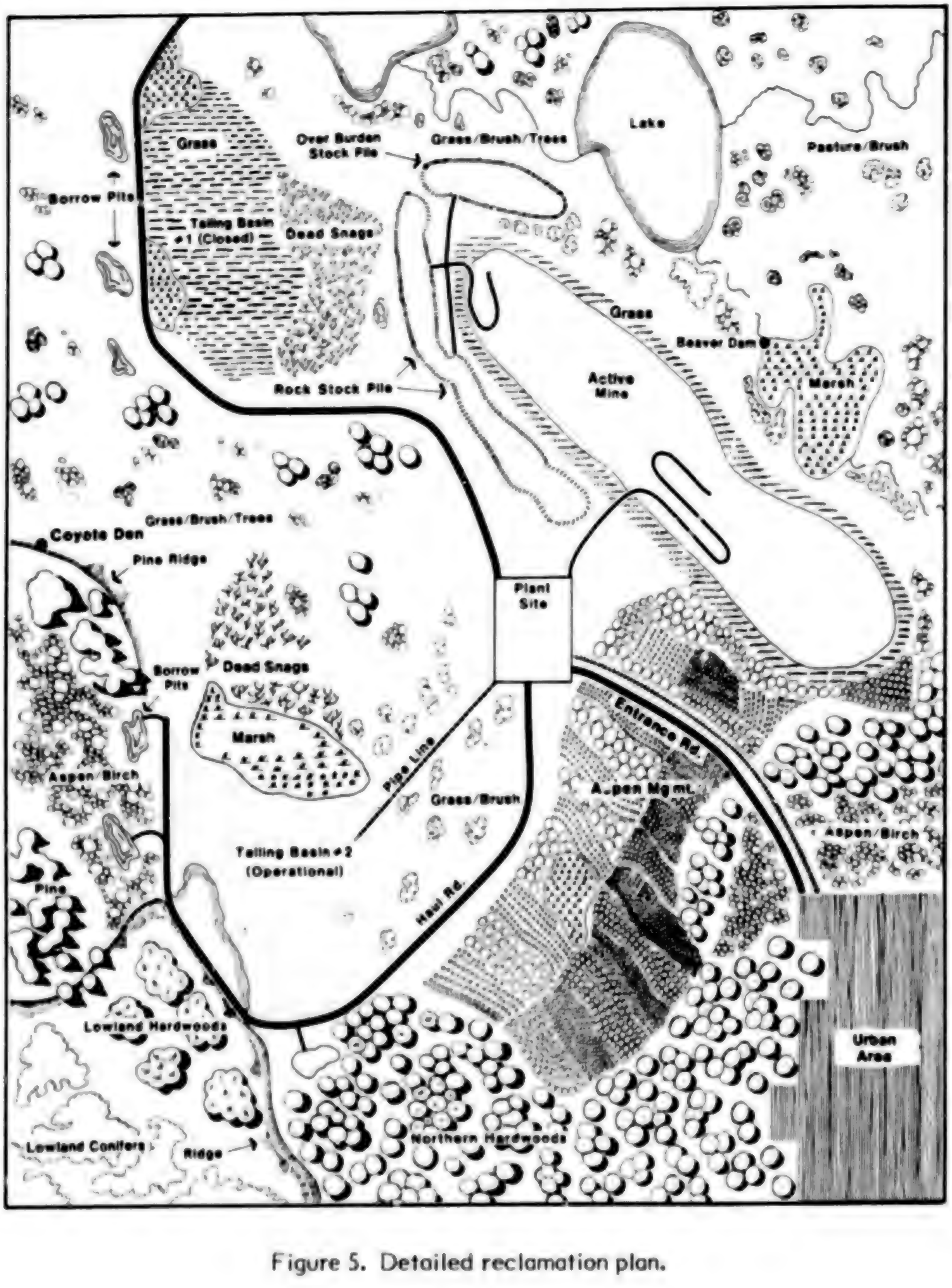


Figure 5. Detailed reclamation plan.

- a detailed description of the mining plan
- contour maps of the mine-mill complex, waste disposal sites, etc.
- vegetation maps
- waste/soil maps
- surface and ground water resource maps
- bedrock geology map

An alternative reclamation plan is developed for each combination of mining plan and compatible land use. The alternatives are compared from the perspectives of regulatory constraints, practical feasibility, and costs to determine the final plan. Once the mining process begins, the reclamation plan is ordinarily implemented as soon as possible. As mining progresses, the reclamation plan is modified as necessary.

PLANNING FOR WILDLIFE HABITAT ENHANCEMENT

The integration of the needs of wildlife in a reclamation plan, at best, is a difficult and inexact science. In general, any vegetated area will attract certain species of wildlife; some areas are just better than others. The aim of this manual is to promote the conscious consideration of wildlife needs in reclamation planning. Properly planned and managed, a mine site reclaimed for any end use involving the establishment of vegetation can serve both man's commercial ventures and the needs of wildlife without significantly slighting either.

The last section of this manual is a worksheet with instructions for its use to aid the land manager in integrating the needs of wildlife in the reclamation plan. This worksheet was designed to be used in conjunction with a site map on which the basic reclamation plan has been delineated. The worksheet will help the land manager to adjust the plan by identifying the wildlife habitat management techniques that could be used in conjunction with other land uses, such as commercial forestry or pasture land.

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SUMMARY OF ENVIRONMENTAL FACTORS

In the Upper Midwest, mineland reclamation will normally involve revegetation of mines site for forestry, agriculture, and wildlife habitat. The ability of the mineland to support vegetation primarily depends on appropriate topography, soils, and climate.

In general, topography directly affects revegetation efforts, water quality, and possible land uses. The steep slopes found on any open-pit mining sites promote runoff and erosion, making it difficult to establish vegetation.

The soil must have the appropriate physical and chemical properties if revegetation is to be successful. Of the four types of mining wastes -- overburden, tailing, waste rock, and lean ore -- only overburden, waste rock covered with overburden, and tailing are likely to offer practical opportunities for revegetation.

Climate, of course, cannot be altered, but it is important nonetheless. For revegetation efforts to succeed, adequate precipitation must be available. Equally important are the microclimatic conditions found on a mine site; these can be altered to some extent to benefit vegetation.

This section summarizes the significance of topography, soil, and climate and discusses the importance of each in the environment of Upper Midwest mining areas. Table 1, at the end of this section, summarizes the conditions associated with each factor.

TOPOGRAPHY

Natural landscapes usually contain a variety of landforms. These landforms largely control the movement of soil and water, which directly affects the success of any revegetation program. The two most significant problems are erosion and runoff.

Locations subject to severe erosion do not readily provide the environment required to support extensive vegetation. Landforms with stable soil surfaces provide the best conditions. This stability is best ensured by the presence of plant cover. In the absence of vegetative cover, a mulch can be used in some instances to stabilize the soil; however, mulches provide only short-term stability. Long-term stability requires extensive vegetative cover. For instance, a barren area subject to erosion might first be planted with a temporary nurse crop, such as a fast-growing herbaceous species. After the nurse crop has stabilized the soil, the introduction of other plants would be possible.

Redistribution of water and soil from upper to lower slopes can threaten the survival of plants on upper slopes. This is a problem especially where the moisture retention capacity of the soil is low. Therefore, plant species capable of withstanding drought conditions should be favored on upper slopes.

PHYSICAL SOIL PROPERTIES

The soil's physical characteristics greatly influence its ability to produce plants. In overburden and tailing, the supply and availability of moisture, nutrients, and oxygen to the plant root system are largely related to:

- texture
- organic matter
- compaction
- rock content
- drainage

Texture

Soil texture refers to its composition, specifically, the relative proportions of different-sized particles.* The basic soil texture groups are sands, silts, and clays. Sands are coarse, clays are fine, and silts are intermediate in size. The percentage of each of these texture groups in the uppermost soil layer determines the soil's primary physical characteristics. Figure 6 illustrates the general soil texture classification system.

Sandy soils tend to be droughty, acidic, and infertile. They are porous, providing ample root aeration. Because of their porous nature, these soils are easily worked and not as susceptible to erosion as other soils.

Clay soils are characteristically plastic and are prone to stickiness, swelling, and shrinking. Clay is generally a poor planting medium because its density impedes root growth and inhibits root aeration.

Loamy soils (fairly even mixes of sand, silt, and clay) are intermediate in their characteristics, providing ample moisture and nutrients to plants. Normally, these soils are easily worked, with little resistance to plant roots or machinery. As the proportion of silt and very fine sand increases, however, the soil is more susceptible to water erosion. Generally, loamy soils contain large amounts of these materials and consequently are subject to serious erosion.

The texture of overburden could range from clay soils to very coarse sands and gravels, depending on the properties of the glacial drift from which it was derived and waste disposal methods. Consequently, the impact of overburden texture on revegetation plans must be determined on a site-specific basis.

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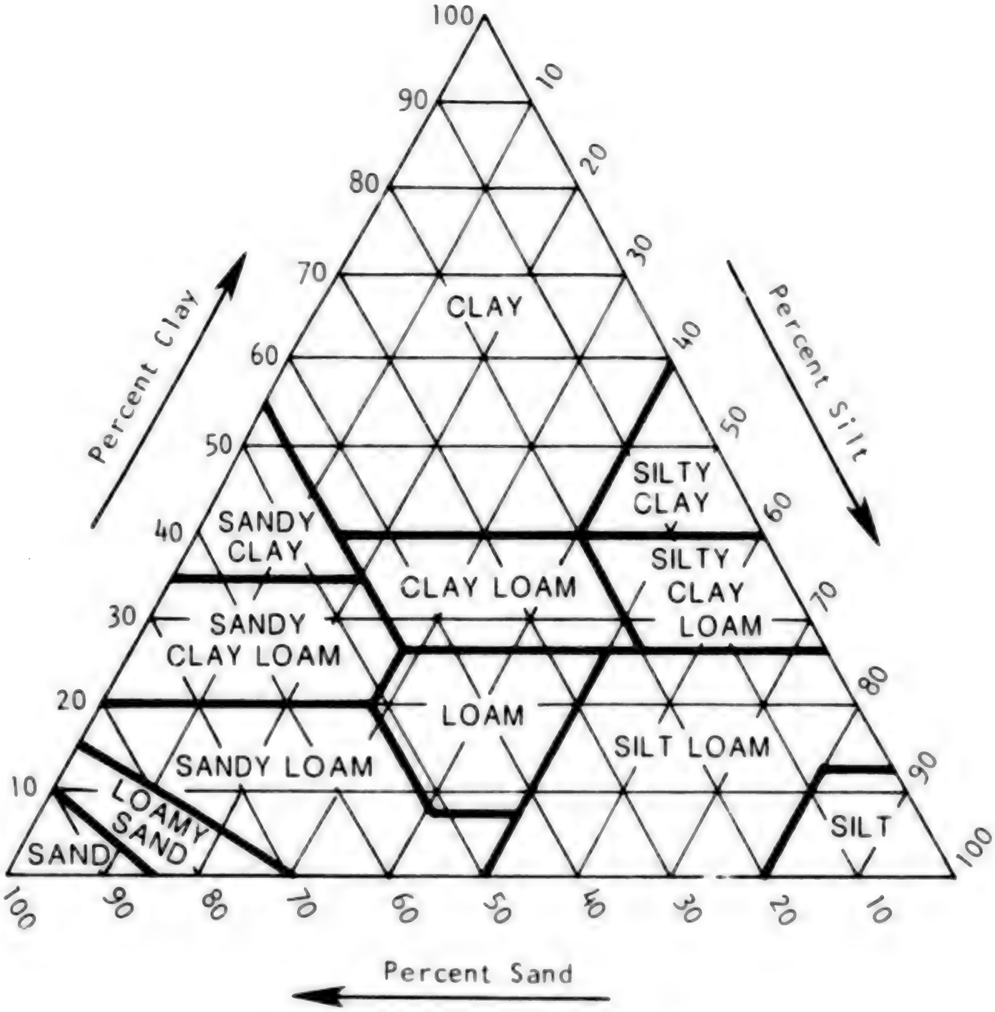
*Methods for field determination are described by Soil Survey staff, 1975, Soil Taxonomy. U.S. Department of Agriculture Handbook No. 436, U.S. Government Printing Office, Washington, D.C.



Source: U.S. Dept. of Agriculture Soil Conservation Service

Figure 6. Guide for textural classification of soil.

The texture of tailing is a function of the milling process and the impoundment environment. Tailing disposal usually results in the separation of various-sized particles, potentially resulting in a wide variety of textures on any site. A site-specific assessment can determine potential impact on revegetation efforts.

Organic Matter

Organic matter results from the accumulation of decaying plant litter and dead root tissue near the soil's surface and is often an integral soil component. Generally, the deeper the organic matter and the darker its color, the greater the benefits of its presence. Overburden generally contains very little organic matter unless it previously supported extensive vegetation. Then, the amount of organic matter depends on the length of time the original vegetation was present. Tailing is devoid of organic matter.

Compaction

During the waste disposal process, various types of heavy machinery compact the soil, making it hard to penetrate for plants, water, oxygen, and some machinery. Compaction impedes revegetation and promotes erosion. Where compaction is severe, its combined effects may preclude revegetation unless the site is prepared through ripping, discing, chisel plowing, or harrowing.

Rock Content

In the glaciated portions of the Upper Midwest, soils may contain a large volume of rock. The presence of solid particles larger than 2mm in diameter reduces the capacity of soil to retain moisture and nutrients and can also impede water penetration. Sandy soils containing a large volume of rock may be less moist and fertile than expected, whereas a loam soil with high rock content may be prone to poor drainage. Although the potential importance of rock content on soil productivity is commonly accepted, quantitative guidelines to evaluate its impact on revegetation efforts are lacking. Generally, to assess the effect of rock content on soil productivity, it is necessary to evaluate its influence on soil moisture capacity and drainage. Rock content of overburden varies depending on the site condition. Tailing generally contains no rock; even the particles in very coarse tailing will not usually exceed 2mm.

Drainage

In mine wastes, drainage is a function of texture, compaction, rock volume, accumulation of fines at the surface, and water table depth. Poorly-drained soils are low in oxygen and contain excess water. Deficiencies of oxygen in the soil can reduce root respiration and growth and increase root resistance to water and nutrient movement. Excess water can induce the solubilization of minerals to toxic levels.

Signs of poor drainage are often visible at the soil surface. Standing water for extended periods is an obvious sign of poor drainage. Examination of the soil below the surface may reveal saturation at shallow depths. Gray-blue soil is an indication of conditions commonly associated with poor aeration. Mottled gray-yellow-orange-red soil normally suggests partial or seasonal conditions of poor aeration.

Plant species differ in their abilities to tolerate poor drainage. Sites with severe drainage problems should be identified and inspected to determine if the problem can be corrected through site preparation or by modifying the surface drainage pattern. If the problem is extensive, corrective measures should be taken if possible. If a small area is involved, it could be considered for its ability to enhance wildlife habitat.

Overburden that has been severely compacted, especially if it has high clay or rock content, may have drainage problems. Fine tailing may also be subject to poor internal drainage, and the tailing impoundment environment could result in saturation at shallow depths.

CHEMICAL SOIL PROPERTIES

Generally, plants require certain nutrients from the soil. For plants to thrive, these nutrients must be continuously present in a form the plant can use.

Of the essential nutrients supplied by the soil, those required in greatest supply are nitrogen, phosphorus, and potassium. Often times, nitrogen and phosphorus are also the most deficient nutrients in overburden and tailing. The most practical method of enhancing soils low in nutrients is the application of fertilizers. Planting nitrogen-fixing plants such as sweet clover and alfalfa can also be helpful.

In general, the overall fertility of overburden is conducive to revegetation; however, plant species must be selected carefully. The comparative infertility of tailing, on the other hand, limits possibilities for revegetation without fertilization. In most cases, nitrogen and phosphorus would have to be added, and some plant species would also require potassium.

To determine nutrient levels in mine and mill wastes, soil tests are generally necessary. These tests can be conducted by various testing laboratories located throughout the Upper Midwest. Some of these laboratories have experience working with mining wastes and can help in interpreting results. Appendix D lists testing laboratories in Michigan, Minnesota, and Wisconsin; only some of these have worked extensively with mining wastes.

When considering the use of fertilizer, the potential for adverse impacts should be explored. Specifically, pollution of ground and surface water resources could be a problem. These adverse impacts can be minimized by using just the amount of fertilizer necessary for the desired results and by discing the fertilizer into the soil to ensure incorporation.

Soil pH is a measure of the soil's acidity or alkalinity and directly affects the relative availability and toxicity of certain nutrients in the soil. Soil pH is measured in units; 7.0 is neutral, and values less than 7.0 are acid and greater than 7.0 are alkaline. In vegetated areas, pH values usually range between 4.0 and 8.0, although higher and lower values are not uncommon. Most plant species can survive and grow within a pH range of 5.0 to 8.0. Where soil pH has restricted plant growth and development, lime, gypsum, acid humus, wood ash, sulphur, and fertilizers have been applied to modify pH levels.

In Upper Midwest mining areas, the pH of overburden usually ranges from 6.0 to 8.0. The pH of taconite tailing generally ranges from 7.5 to 8.5 (pyritic tailing may be very acidic). Tailing resulting from natural iron-ore and copper processing may be either alkaline or acidic depending on the character of the ore body and on the processing method.

CLIMATE

The importance of suitable climate to the growth and survival of vegetation is clear. Vegetation that thrives in the climate of the Upper Midwest is wide-ranging, but it can be adversely affected by microclimatic conditions. As the name implies, a microclimate is a set of weather conditions in a small area different from the general climate of the region. In a mining environment, adverse microclimates can be found in low points and on slopes.

Microclimatic temperature extremes historically have been a frequent cause of vegetation failure in Michigan, Minnesota, and Wisconsin. These extremes are primarily related to topographic position and the reflectivity of soil surfaces.

Topographic depressions or constrictions in a valley often act as accumulation points of cold air. These "frost pockets" can produce low temperatures damaging to plants (especially trees and shrubs) well after the average temperature of the locale has spurred the seasonal growth process. The result is a reduction in net growth and high plant mortality.

The interrelationship of exposure to the sun (insolation) and slope can also have significant effects on local temperature. The hottest slopes are those which most nearly face the sun at noon (slopes which face south). Western slopes are also exposed to direct sunlight during the heat of the afternoon. The greater levels of insolation on these slopes can promote soil dehydration, leading to difficulties in vegetation establishment. For example, southerly slopes tend to warm up faster in the spring, creating the potential for frost damage to plants that germinate early in the season. Selection of suitable plant species can help to prevent such frost damage.

The reflectivity of soil surfaces may interact with insolation to produce another source of local temperature variation. As the reflectivity of a surface increases, the amount of energy absorbed decreases. Generally, the brightness of a surface is directly related to its reflectivity. Therefore, dark soil surfaces can absorb large amounts of energy, resulting in excessive surface temperatures. This can result in the dehydration of seedlings or temperatures too high for satisfactory plant growth and development.

Microclimatic influences in the revegetation of minelands are important because mining landscapes are often diverse, containing a variety of microenvironments. For example, waste stockpiles and exposed pit walls will undoubtedly produce hot, dry southerly slopes. Large, flat tailing basins with low points may create frost pockets. Similar situations can result from the construction of waste stockpiles in close proximity to each other, thus creating "valleys" which could become frost pockets. Differences in the color of various wastes also produce variations in the surface temperatures of these materials. In particular, the dark gray color of taconite tailing can produce very high surface temperatures during periods of low rainfall.

Revegetation of hot dry slopes may be difficult, particularly where the soil is low in moisture capacity (e.g., tailing backslopes, overburden). In some cases, it may be useful to use a nurse crop to encourage the accumulation of soil organic matter and to enhance the soil's moisture retention capacity. This practice, however, requires caution if forestry is the planned land use; the intense competition of herbaceous plants for soil moisture may inhibit the forestation process.

Revegetation of wastes prone to high surface temperatures (e.g., tailing) may benefit from the use of a mulch. Straw, sawdust, or woodchips can be used; appropriate quantities applied to the waste surface should moderate surface temperatures enough to allow plant growth. Mulch materials, however, are generally high in carbon and low in nitrogen. Their application can result in serious nitrogen deficiencies, since the decomposition process requires nitrogen. To counteract this problem, nitrogen fertilizer should be applied.

Table I. Critical Environmental Factors

Factor	Effect
Topography	
Erosion and runoff (due to steep and/or long slopes)	Upper slopes - subject to soil loss and drought. Lower slopes - subject to soil accumulation and moist conditions.
Exposure	South and west aspect - warm and dry. North and east aspect - cool and moist.
Reflectivity	Dark soil - warm or hot. Light soil - cool.
Physical Soil Properties	
Compaction	Limits water infiltration and ease of revegetation.
Drainage	Determines soil moisture, aeration, erosion, and plant species that should be used.
Organic Matter	Affects water and nutrient retention, biologic activity and productivity.
Rock Content	Limits land use, equipment that can be used, and water and nutrient retention.
Texture	Affects erodibility, water and nutrient retention, and plant species used.
Chemical Soil Properties	
Nutrients	Affects productivity and plant selection.
pH	Affects liberation of heavy metals, water quality, plant selection, and nutrient availability.
Climate	
Frost Pockets	Limits end use and plant species used.

RECLAMATION FOR FORESTRY

Approximately 43 percent of the land area in Michigan, Minnesota, and Wisconsin is forested. This land base supports a forest industry which produces secondary woodproducts including pulp, paper, posts, poles, lumber, ties, veneer, cooperage, cabin logs, particle board, flake board, composition board, fuelwood, and Christmas trees. Recently, increasing urban, industrial, and recreational development has reduced the amount of land available for commercial forestry. Nevertheless, the demand for wood products continues to increase.

Properly managed, forested minelands are capable of producing the primary wood products ordinarily associated with commercial forestry. Forest cover provides protection against soil erosion and has long been recognized for its value in watershed protection. Also, trees have been used successfully to screen unsightly landscapes from public view. Regardless of the specific commercial purpose of forestation, planting programs can usually be designed to provide quality wildlife habitat.

OPERATIONAL CONSTRAINTS

The practice of commercial forestry in any area requires the economical tending and harvesting of forest crops. Post-mining landscapes do not necessarily lend themselves to these activities. For instance, stockpile slopes may be too steep for standard forestry equipment. Irregular stockpile topography or abundant surface rock may limit access by forestry equipment or inhibit the planting process. Mine wastes (e.g., poorly drained tailing) may not support heavy forestry equipment. In addition, small forest stands (less than 10 acres) may not be profitable.

FORESTATION STRATEGIES

Reclamation for forestry on minelands in the Upper Midwest could be accomplished through natural or artificial forestation.

Natural Forestation

Any barren land constantly receives the seeds or spores of plants from adjacent vegetation. Thus begins the natural process of plant colonization. The new plants appearing on a bare site would include only those species whose nutrient and moisture requirements are met by the site and whose tolerance of critical environmental factors (e.g., soil heat) are not exceeded. Because the mineland environment is largely controlled by man, the rate of natural forestation can be altered depending on the objectives of the reclamation plan.

Seeds of native and commercial forest tree species typically invade overburden and develop according to a predictable pattern. In the early stages, grasses, legumes, and occasional aspen and birch seedlings colonize the site. Gradually, scattered woody plants develop and eventually dominate the area. In the next stage, the site grows into an immature forest. After 50 years of natural development, the resulting aspen-birch forest is similar to undisturbed forest lands and could support commercial forestry.

Successful use of natural forestation as a reclamation strategy is probably limited to overburden; further, it depends on accelerating the rate of the process. This might be accomplished through surface treatments such as scarification, ripping, chisel plowing, etc. to produce a porous, noncompacted seedbed. Water and sediment control features may also be useful. The major advantage of natural forestation is its economy, but it also involves increased risk of failure. Therefore, natural forestation should be restricted to remote overburden areas with good seedbed conditions and little potential for erosion.

Artificial Forestation

Forests can be established artificially through direct seeding or planting.

On minelands, direct seeding trials have been limited and the results have been variable and poorly documented. On undisturbed forest lands, experience suggests that two forest tree species (jack pine, black spruce) can be regenerated through direct seeding. For best results, seeds should be treated with bird and rodent repellents (Arasan) and sown during the spring at a rate of from two to four ounces per acre. Success of direct seeding on well-prepared sites depends on favorable weather conditions during seed germination and establishment. Therefore, the technique should be limited to those areas with moist soils and frequent rain during the spring and early summer.

Successful planting programs ordinarily involve five phases:

- selection of suitable planting sites
- selection of suitable tree species
- selection of suitable plant materials
- site preparation
- cultural treatments

Selection of Suitable Planting Sites. Sites are usually unsuitable for planting when they are subject to frequent late frosts, inundation, severe erosion, severe drought, and frost heaving. To the extent possible, these sites should be identified and their boundaries mapped. Depending on the degree of the problem, these areas might be forested through a combination of appropriate species selection, site preparation, and cultural treatment. As an alternative, small open areas in a forested landscape could be used to enhance wildlife habitat.

Selection of Suitable Tree Species. Proper selection of forest tree species requires analysis of the environmental factors discussed earlier. Contrasting environments within the planting site should be identified and mapped. Table 2 shows suitable

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Table 2. Forest Trees Species Requirements and Suitability to Hard Rock Mining Wastes

Species	Minimum Requirements							
	Preferred Soil Texture	Shade Tolerance[1]	pH	Moisture	Exposure	Insect & Disease Limitations	Suitable Wastes[2]	Comments
Red Pine	loamy sand-sandy loam melanized sands	intolerant	4.5-6.0	low-moderate	N+E,S+W	very susceptible to damping-off disease	GLO,LO,ROT	Does not grow where surface soil is alkaline; occurs only sporadically on heavier textured soils because of inability to compete with more aggressive hardwoods.
Jack Pine	coarse, melanized sands & gravels-loamy sands	very intolerant	4.5-6.5	low	N+E,S+W	----	GLO,LO,ROT	Will grow satisfactorily on alkaline soils provided normal mycorrhizal associations are present; has low requirements for organic matter and nutrients.
Eastern White Pine	sandy loams-loams	intermediate	4.8-7.3	moderate	N+E	white pine blister rust, white pine tip weevil	GLO,ROT	Tolerant of full soil and moisture gradient from wet bogs to xeric sands.
Scotch Pine	loamy sand-sandy loam	intolerant	4.5-6.0	low-moderate	N+E,S+W	----	GLO,LO,ROT	Resistant to frost and drought; has wide ecological amplitude, surviving on barren sands to sphagnum bogs, not suited for heavy, alkaline soils.
Balsam Fir	heavy loams-silt loams	very tolerant	4.0-6.0	moderate-high	N+E	spruce budworm heartrot	----	Sensitive to drought, acid tolerant (pH < 4.0), high requirements of organic matter, prone to windthrow.
White Spruce	loams, gleyed loams, alluvium	tolerant	4.8-6.5	moderate	N+E	spruce budworm	----	A very nutrient demanding conifer, prone to late frost damage; prefers acidic soils but will tolerate circumneutral and alkaline soils.
Black Spruce	well decomposed organic soils, mineral soils across most textural classes	tolerant	4.0-6.5	moderate-high	N+E	----	----	Very acid tolerant, susceptible to windthrow.
Norway Spruce	sandy loams-dry loams	tolerant	4.8-6.5	moderate	N+E S+W on heavy soils	fomes annoses	----	Tolerates poor aeration and strongly acid reaction; suffers from fungus diseases on neutral or alkaline soils.
Tamarack	well decomposed organic, moist well-drained loams	very intolerant	4.5-6.5	high	N+E	larch sawfly	----	Prolonged flooding will kill it; tolerates extreme acidity and has low nutrient requirements; found on soil textures from heavy clays to coarse sands.

Table 2. Forest Trees Species Requirements and Suitability to Hard Rock Mining Wastes

(Concluded)

Species	Minimum Requirements							
	Preferred Soil Texture	Shade Tolerance[1]	pH	Moisture	Exposure	Insect & Disease Limitations	Suitable Wastes[2]	Comments
European larch	sandy loam, loam, silt loam, clay loam	very intolerant	4.5-6.5	moderate-high	N+E	----	----	----
Trembling & Big Tooth Aspen	loamy sands, sandy loams, loams-clay loams	very intolerant	4.8-7.0	moderate	N+E,S+E	forest tent caterpillar, hypoxylon canker	GLO,LO,ROT WR	Some of the best stands are found on glacial calcareous drift, fairly resistant to acidic soils and droughty conditions; does poorly on coarse sands and stagnant swamps; typical pioneers with great seedling & sprouting capacities.
Balsam Poplar	calcareous clay loams, silt loams, alluvial bottoms, swampy sites with a shallow layer of organic soil	very intolerant	5.0-7.0	high	N+E	----	GLO,ROT,LO	Abundant moisture more important than a specific soil texture; seedbed must be continuously moist for an extended period after the germination period; regenerates vegetatively from stump sprouts, root suckers and cuttings; a pioneer species.
Hybrid Poplar	sandy loams, silt loams, certain clones suitable on coarser soils	very intolerant	5.5-8.0	moderate-high	N+E	----	GLO,ROT,TT	Generally intolerant of vegetative competition.
Paper Birch	well-drained sandy loams	very intolerant	5.0-5.7	low-moderate	N+E,S+W	----	GLO,ROT,WR, LO	Resistant to sunscald and frost, tolerates acidic bog soils; a pioneer species capable of producing large quantities of seed.
Willow	almost any soil texture if it has a continuous moisture supply in growing season.	very intolerant	6.0-8.0	moderate high	N+E	----	ROT,TT	Pioneer-type species which produces large quantities of seed disseminated long distances by air and water; root cuttings are a successful means of regeneration.

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[1] The five classes of tolerance (very tolerant, tolerant, intermediate, intolerant, very intolerant) are based on the minimum percentage of full sunlight for a species to survive in the understory (Spurr & Barnes, 1980):

Very tolerant:	when light irradiance is as low as 1-3% of full sunlight
Tolerant:	when a species typically requires 3-10% of full sunlight
Intermediate:	when a species typically requires 10-30% of full sunlight
Intolerant:	when a species typically requires 30-60% of full sunlight
Very tolerant:	when a species typically requires at least 60% of full sunlight

[2]

GLO	Glacial overburden
LO	Lean ore
ROT	Red ore tailing
TT	Taconite tailing
WR	Waste rock

Sources: U.S. Department of Agriculture (1965), Curtis (1959) Wilde (1976), Spurr & Barnes (1980), Bakuzis & Hansen 1960, Michigan State Univerity (1978) tree species for mineland forestation projects. The table also describes the requirements of each.

Selection of Suitable Plant Materials. After the tree species have been selected, the plant material to be used to introduce the species to the site must be determined. Three kinds of materials may be suitable for use in the reclamation of Upper Midwest minelands:

- bare-root stock
- containerized seedlings
- cuttings

In the past, the vast majority of minelands were forested using bare-root stock. Given suitable weather conditions, overburden waste can be planted successfully with bare-root stock. Bare-root plantings on tailing and lean ore, however, are usually less successful. The most common problem is digging a planting hole in rocky areas.

Containerized seedlings show promise for use in mineland forestation. Although more expensive than bare-root stock, containerized seedlings offer several advantages, including shorter cultivation time, extended planting season (possibly through August), and easier planting on rocky sites. Experimental plantings of containerized seedlings are presently being conducted, but meaningful results are not likely for some years.

Many tree species can be cultivated from cuttings. The use of this technique has been limited in the Upper Midwest, but it has potential. Generally, cuttings are capable of rapid ground cover production; however, the method is limited to use where the desired species is adaptable to the method of cultivation. Both rooted and unrooted cuttings are available. Rooted cuttings are more expensive, but on sites with severe problems, they are more likely to be successful than unrooted cuttings.

For the near future, bare-root stock is likely to remain the most popular method of introducing desired tree species to the planting site. As experience is gained in the use of containerized seedlings and cuttings, these techniques may become more popular. Bare-root stock and containerized seedlings can be obtained from state and federal nurseries and from private growers. Cuttings can often be obtained from the same sources on a limited basis. In some cases, suitable cuttings can be gathered from adjacent lands. Seed and planting stock sources are listed in Appendix E.

Site Preparation. Areas needing physical or chemical modification to ensure tree survival and growth should be treated prior to planting. Site preparation might include access, compaction, erosion, and soils reaction treatments.

Rocky or hilly terrain may limit access to the planting site. Various types of grading equipment can be used to level or bury physical obstructions.

Severely compacted sites that inhibit the planting process or threaten plant survival and growth can be treated by ripping, discing, chisel plowing, or harrowing. Specific treatments vary with site conditions and the size of the area. Planting of mechanically-treated sites may need to be delayed until the soil has had a chance to settle. This will eliminate dry air pockets in the rooting zone. Air pockets can also be partially eliminated with a second light discing or harrowing.

Sites with potential for serious erosion should not first be planted with forest trees. The site should be stabilized through the use of erosion control structures and/or cultural treatments (to be discussed). Once the soil is stable, planting can proceed; however, the planting method must not aggravate the erosion problem.

Extremely acidic or alkaline mining wastes are not good planting media for forest trees. Although some species (see Table 2) can tolerate moderate acidity or alkalinity, they are often less productive. Treatments for excessive acidity include topsoiling with overburden and applications of lime or sewage sludge (before using sludge, possible regulatory constraints should be reviewed). Treatments for alkaline wastes might include applications of acidic peat, gypsum, sulphur, sulfuric acid, lime sulphur, iron sulfate, and aluminum sulfate.

Cultural Treatments. The survival and productivity of forest plantings can often be enhanced through various types of cultural treatments. Disturbed minelands in the Upper Midwest may benefit from application of surface mulches; fertilizing with nitrogen, phosphorus, and potassium; or use of nurse crops.

Minelands in the Upper Midwest are often low in soil moisture, soil surfaces may be very hot and devoid of protective vegetative cover, and erosion may threaten seedling survival. The application of surface mulches to barren, unvegetated ground ordinarily helps by conserving soil moisture, lowering surface temperatures, and controlling wind and water erosion. Mulches suitable for use on Upper Midwest minelands include straw, hay, sawdust, woodchips, bark, and wood pulp.

Although they are not in extensive use in forestation programs, other materials show promise for use as surface mulches, such as excelsior mats, sewage sludge, asphalt, and latex and resin.

Mulches are not without problems. With the exception of sewage sludge, organic mulches may induce nitrogen deficiencies. Organic mulches often act as a source of undesirable organisms such as weeds, pathogens, and insects. Mulch cover may attract small rodents. As these animals browse, they often girdle small tree seedlings, reducing the rate of seedling survival.

Most mining wastes contain some soil nutrients. Nevertheless, fertilizing with nitrogen, phosphorus, and possibly potassium will usually benefit many forest tree species. Fertilizer needs on each planting site should be determined by soil testing. Fertilizer applications, as with any other chemical treatment, have the potential to damage some resources. Nevertheless, when used properly, the benefits derived from chemical treatments far outweigh the negative effects.

Nurse crops may be useful in the forestation of unvegetated mining sites. Nurse crops can provide rapid, temporary stabilization, protection against erosion, organic matter, and modification of the microenvironment. Some good nurse crops for woody plants are combinations of annual oats, annual barley, legumes, and perennial grasses.

Though experience with them is limited, the use of nurse crops to promote forestation of minelands appears to have excellent potential. Because a balance between stabilizing cover and competing woody cover must be obtained, seeding rates of nurse crops for mineland forestation should probably be lower than for agriculture.

The actual rates will depend on the species used. A disadvantage of planting nurse crops in conjunction with woody vegetation is the possible development of large rodent populations, which can seriously damage shrubs and trees.

FORESTRY PRACTICES BENEFICIAL TO WILDLIFE

The production of forest crops does not always provide an attractive habitat for wildlife. Nevertheless, incorporation of various wildlife habitat management practices in a forestry management program can enhance forestry operations for wildlife without significantly affecting forest crop production.

For example, Christmas tree production can be planned for rotating harvests to allow understory areas to remain unshaded, while developing a variety of tree sizes in the area. A border of shrubs comprising several rows of different species, as well as gaps in the Christmas trees to allow for rows of shrubs, would provide for additional wildlife habitat.

Forest plantations for sawlogs, pulp, posts, or other forest products can also be enhanced by providing more diverse plant cover within the forest to increase the variety of food and cover types. Single species stands of hardwoods may be separated by planting several rows of conifers or grass/legume strips between stands. Single or double tiers of shrub borders around the edge of these stands would also be beneficial.

Breaking up large tracts of timber into smaller stands by using rotating harvests would be very beneficial to wildlife. Other techniques include the following.

Openings and Trails

Openings can be created or maintained by not planting small areas of barren sites and cutting, bulldozing, and using chemicals or fire on vegetated sites. Cutting is the simplest method. All trees should be removed in a selected area, taking care not to remove too many berry- or mast-producing trees and shrubs. The soil disturbance created by bulldozing will spur herbaceous plant growth. The use of plant-killing chemicals to create openings has been effective only when used repeatedly; only chemicals approved by regulatory agencies and which do not destroy desirable plants should be used.

Seasonal or abandoned logging roads are good examples of areas that lend themselves to trail development. These abandoned roads can be seeded with clover or alfalfa as well as with several rows of shrubs, thus providing food and cover along the wildlife corridor. Another possibility is a trail across a southeasterly-facing slope just above lowland and brush areas. This would provide nesting spots for grouse, encourage edge growth of herbaceous plants and food-producing shrubs, and ensure early availability of green plants in spring by exposing the south slope to the sun. Such a trail would also provide woodcock habitat and a natural route for deer.

Forest openings need not be large. One- to two-acre openings scattered in three or four locations in a 40-acre stand would be ideal for ruffed grouse as well as deer. When managing for grouse, openings near stands of large conifers, which give raptors an advantage over grouse, should be avoided.

Methods of Harvest

A number of harvest operations are especially beneficial to wildlife because they promote diversity. Winter logging, small cutting sites, short-term reforestation, and even-age cutting are good examples.

Winter logging near traditional deer yarding areas provides supplemental browse during the winter season, the most critical period of the year. In planning winter logging operations, deer yarding areas (areas that provide the deer with thermal cover, i.e., stands of conifers) should be identified to ensure that the yarding areas are not destroyed during logging operations. Small cutting sites, though probably not the most efficient method of timber management, would provide the greatest benefit to deer. Ideally, an area stocked with trees less than five years of age should be no more than two miles from any point in the deer range.

Similar to small cutting sites, short-term reforestation retains a larger proportion of the forest in the young-tree, open-canopy stage which is favorable to deer browse production. Even-age cutting, a typical practice in pulp production, results in clear-cutting various-sized stands of trees. This approach can be used to develop and maintain a habitat that would benefit wildife, particularly deer and ruffed grouse.

Providing Food-Producing Trees and Shrubs

Planting berry bushes to attract grouse and non-game birds is an effective management tool. These bushes are best planted in long, zig-zag rows in clearings approximately 20 yards from woodlots. Other management methods include maintaining narrow corridors and stimulating browse- and berry-producing trees and shrubs by clearing areas around existing clumps of these preferred plant species. High bush cranberry, thornapple, mountain ash, and smooth sumac are some preferred wildlife foods. Mountain maple and red-osier dogwood are good deer attractors.

Incorporating low-lying areas such as frost pockets and wetlands into a forestry management plan rather than eliminating them will provide habitat for a wide variety of wildlife species. These low-lying areas can be further enhanced by bordering them with grasses and shrubs which provide buffers and runways for ground-dwelling birds and mammals that use wetland areas as a water source.

Other techniques used to establish food and cover for wildlife in a managed forest would include leaving large boulders and logs, snags, and brush piles for escape cover and observation points. Initially, supplementary artificial food patches could be planted to provide food until permanent food-bearing plants become established.

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RECLAMATION FOR AGRICULTURE

In Michigan, Minnesota, and Wisconsin, agriculture is a major land use; however, it is limited in these states' mining areas. Currently, some experiments are being conducted to test the potential for hay, grain, and potato production on abandoned minelands. Pasturelands have been developed on mining wastes in other regions. Because of the physical characteristics of mine wastes and the climate of the Upper Midwest, grazing and hay production would be the most likely (though limited) applications of reclamation for agriculture. The tops of surface overburden stockpiles and the interiors of tailing basins might be adaptable to agriculture, particularly to grazing and hay production. In rare instances, it may be possible to develop other types of agriculture, such as row crops and orchards; however, these applications will not be considered in this manual.

The ground in areas to be reclaimed for agriculture should slope six horizontal to one vertical (6:1) or less. Such slopes minimize potential erosion problems should these areas be overgrazed. In addition, these slopes are not too steep to use harvesting equipment. Slopes of less than 6:1 can also be used for pasture; however, if livestock grazing destroys plant cover, erosion could become a problem.

When considering reclamation of surface overburden for agriculture, the rock content of the area must be determined. Only areas where rock content will not prevent the use of standard agricultural equipment should be considered for agricultural reclamation. High rock content is normally not a problem in mill waste or tailing.

Plant cover used for reclamation of mining areas for agriculture areas will ordinarily comprise grasses or grass/legume mixtures. Since most mineral wastes are deficient in nitrogen, it is important to plant legumes or clovers in the vegetal cover. These "nitrogen-fixing" plants will supply the soil with the nitrogen necessary to sustain healthy plant cover. If only grasses are planted, refertilization will probably be necessary periodically to maintain desired productivity levels.

SITE PREPARATION TECHNIQUES

In the preparation of an area to be reclaimed for agriculture, large rocks or other obstructions should be buried or otherwise disposed of. The area should be graded to eliminate steep slopes. If topsoil is available, it could be used to cover the mining wastes. To solve compaction problems, the site should be chisel-plowed or disced to increase permeability and ease root penetration. To minimize erosion, the site should be graded and disced parallel to site contours.

Fertilizer Application

Soil fertility and the need for fertilizer can be checked through normal soil testing. Although agricultural testing methods may not be highly accurate in determining the nutritional levels of various mining wastes, they do indicate deficiencies or excesses. Should fertilizer be necessary, applications will vary markedly depending on the characteristics of a particular mineral waste. An example is taconite tailing, which might require as much as 600 pounds of 11-55-0 fertilizer per acre. On the other hand, overburden might require only 200 pounds of 20-20-20 fertilizer per acre.

Two methods of applying fertilizer are normally used on mining and milling wastes: (1) in a slurry, using a hydroseeder or (2) dry, using a broadcast seeder. When dealing with infertile taconite tailing, it is important to work the fertilizer into the tailing. In flat areas, this can be done with a disc. On slopes steeper than 2.5:1, it can be done with a clodbuster (a long, spiked chain with a counterweight at the end hooked to a small crawler tractor. This configuration allows the tractor to move along slope ridges while the counterweight pulls the cable down across the slope, smoothing the slope's surface and working in any fertilizer that has been applied.)

Seeding Methods

The method of seeding often depends on the mining waste. If the topography is level and contains little rock, a range drill seeder can be used. This method is effective because it places the seed in the ground and covers it. In other instances, a broadcast seeder is most effective. This is especially true when planting irregular, rocky areas or wet, silty areas which tend to clog up a drill seeder. When using a broadcast seeder, it is important to follow it with a steel roller which presses the seed into the soil, preferably at right angles to the slope to reduce the potential for soil erosion. On steep slopes, a hydroseeder can be used. The seed can then be covered through use of a clodbuster or a chain dragged across the slope's suface.

PLANTING AND PLANT MATERIALS

When selecting plant species, final land use must be considered. It is important to use plant species well-adapted to the area and capable of providing permanent cover. Since most mill wastes from the mining industry are deficient in nitrogen, wherever possible, legumes capable of fixing nitrogen from the atmosphere should be used. For successful establishment of legumes, it is normally necessary to inoculate the seed with nitrogen-fixing bacteria. Once established, grass/legumes cover should not need to be refertilized with nitrogen. Tables 3 and 4 list plant species and seed mixes which have been used in this three-state area for the reclamation of minelands and mineral wastes.

If the area is to be used for livestock feed, the plants must be palatable and not cause problems (e.g., bloat) in livestock. Plant species also cannot contain noxious weeds which will cause problems for adjoining land owners.

Table 3. Agricultural Plant Species Recommended for Hard Rock Mining Wastes

	Growth Habitat	Soil Preference	Site Preference	Erosion Control	Temp. Stabilization	Pasture	Hay
Grasses							
Canada bluegrass	C-SF	AC/AL	VAR	X		X(L)	
Colonial bentgrass	C-SF	AC/AL	VAR	X			
Crested wheatgrass	C-B	AC/AL	DRY	X		X	X
Durar hard fescue	C-B	AC/AL	VAR	X			
Garrison creeping foxtail	C-SF	AC/AL	MOIST	X		X	X
Green needle grass	C-B	AC/AL	VAR	X		X	X
Intermediate wheatgrass	C-SF	AC/AL	DRY	X	X	X	X
Kentucky bluegrass	C-SF	AC/AL	VAR	X		X	
Orchard grass	C-B	AC/AL	VAR	X		X	X
Perennial ryegrass	C-B	AC/AL	VAR	X	X	X	X
Red fescue	C-B	AC/AL	VAR	X		X	
Redtop	C-SF	AC/AL	MOIST	X		X	X(L)
Reed canary grass	C-SF	AC/AL	MOIST	X		X	X
Smooth brome	C-SF	AC/AL	VAR	X		X	X
Switchgrass	W-SF	AC/AL	VAR	X		X	X
Tall fescue	C-B	AC/AL	VAR	X		X	
Tall wheatgrass	C-B	AL	VAR	X		X(L)	
Timothy	C-B	AC/AL	MOIST	X			X
Western wheatgrass	C-SF	AL	VAR	X		X	X
Slender wheatgrass	C-B	AL	DRY	X	X		
Legumes							
Alfalfa		AC/AL(L)	VAR	X		X*	X
Alsike clover		AC/AL(L)	MOIST	X		X	X
Birdsfoot trefoil		AC/AL(L)	VAR	X		X	X
Cicer milkvetch		AC/AL(L)	VAR	X		X	X
Crown vetch		AC/AL(L)	VAR	X		X	X
Red clover		AC/AL	MOIST	X		X	X
Sweet clover		AC/AL	VAR		X	X(L)	X(L)
White Dutch clover		AC/AL(L)	VAR	X		X	
Grain							
Barley		AC/AL	VAR		X		
Buckwheat		AC/AL	VAR		X		
Millet		AC/AL	MOIST		X		
Oats		AC/AL	VAR		X		
Rye		AC/AL	VAR		X		

C	Cool season
B	Bunch grass
SF	Sod former
AC	Acid
AL	Alkaline
VAR	Variable
(L)	Limited
*	Can cause bloat in cattle
W	Warm season

Sources:

Donovan, et al. (1976)
Phillips Petroleum Co. (1963)
U.S. Department of Agriculture (1972)

Table 4. Examples of Seed Mixtures Recommended for Hard Rock Mining Wastes*

Taconite Mining Minnesota	
A. Coarse Tailing	lbs/acre
Intermediate wheatgrass	15
Smooth brome	10
Perennial ryegrass	5
Alfalfa	8
Sweet clover	8
Total	46
Canada bluegrass	10
Red fescue	10
Perennial ryegrass	10
Alfalfa (rhizoma var)	10
Birdsfoot trefoil	5
Total	45
Smooth brome	20
Red top	5
Perennial ryegrass	5
Alfalfa	5
Birdsfoot trefoil	10
Total	45
B. Fine Tailing	
Rye grain	30
Sweet clover	6
Alfalfa	6
Red top	5
Total	47
C. Temporary Stabilization	
Rye grain	30
Reed canary grass	10
Alsike clover	6
Sweet clover	6
Red top	4
Total	56
Barley	75
Millet	30
Rye grain	90
D. Surface Overburden	lbs/acre
Red fescue	10
Smooth brome	5
Sweet clover	15
Timothy	5
Perennial ryegrass	8
Total	43
Red fescue	10
Smooth brome	15
Sweet clover	5
Birdsfoot trefoil	10
White Dutch clover	5
Total	45
Low Grade Iron Ore Mining - Michigan	
A. Tailing Dikes and Overburden	
Ryegrass	10
Sweet clover (yellow)	5
Alfalfa (vernal)	5
Red fescue (creeping)	10
Buckwheat	100
Total	130
B. Tailing	
Fescue	10
Smooth brome	10
Red top	10
Reed canary grass	10
Sweet clover (yellow)	5
Alfalfa (vernal)	5
Barley	96
Total	146
Copper Exploration - Wisconsin	
Exploration Sites or Access Roads	
Kentucky bluegrass	6
White Dutch clover	8
Oats	32
Total	46

*These seeding mixtures are the product of the trials of various people in the mining industry who have pioneered the technology development for field reclamation practices. The seeding mixtures in this table are intended to serve only as guidelines. Actual mixtures may need to be varied depending on the specific conditions of the site to be reclaimed.

USE OF MULCH

Mulching may be necessary when planting south slopes and dark waste materials because of high temperatures and dehydration problems. Hay, straw, and wood fiber mulches have all been used for agricultural revegetation. A disadvantage of using hay mulch is the weed seed present in the hay. Hay and straw mulches are normally applied with a conventional blower at the rate of two tons per acre. In flat areas, the mulch can be anchored using a serrated straight disc that punches mulch into the ground. On steep slopes (less than 3:1), where it is not possible to use such a disc, an asphalt tack (200 gallons per acre) or other tack can be used to anchor the mulch. Anchoring with a disc or a tack should be done at right angles to the slope. Wood fiber mulch is applied in a slurry using a hydro-mulcher (between 1,500 and 2,000 pounds per acre). Chemical mulches have also been used to stabilize sites and to prevent sandblasting of newly-emerged plant materials; however, some chemical mulches inhibit the emergence of small plants, so such mulches should be selected carefully.

VEGETATION MANAGEMENT

Land management after reclamation is very important. If livestock are allowed to graze in an area too soon, they can destroy the vegetation before it effectively stabilizes the area. Up to five years may be required for a reclaimed area to become sufficiently well established to permit grazing.

Once the grazing area is established, the carrying capacity of the vegetation must be determined. (Carrying capacity is the number of livestock that can graze in an area without depleting the established vegetation base.) At present, little is known about the carrying capacity of reclaimed minelands. Until more information is available, procedures for determining carrying capacity on rangelands should be used.* Once the carrying capacity is known, the area should be fenced off and a rotation system established that will maximize the effectiveness of the vegetation and prevent its destruction. During the early years of development, it may also be necessary to refertilize or reseed some areas to obtain the kind of dense vegetative cover that will eventually sustain itself.

AGRICULTURAL PRACTICES BENEFICIAL TO WILDLIFE

Plant cover types in an agricultural operation are predominately monotypic (little differentiation in plant species). Generally, these areas are not attractive to wildlife because diversity is the basic principle of wildlife management. Some things, however, can be done to enhance an agricultural operation for its wildlife habitat potential.

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*These procedures are discussed in the National Range Handbook, U.S. Department of Agriculture, Soil Conservation Service.

Mowing

Mowing should be delayed, if possible, until August 1 to prevent destruction of any ground nesting birds. Mowing in the fall will provide stubble and young plants for geese during migration. Unmowed alternating strips will provide food and winter cover for birds and small mammals. These unmowed strips will also provide early nesting cover during the following spring.

Supplementary Plant Species

Tree and shrub borders can be planted around the edge of fields to provide food and cover. Large fields can be subdivided by windbreaks composed of tree and shrub species preferred by wildlife. Island plantings of trees, shrubs, and grasses and legumes will provide added habitat diversity in large pastures or hayfields.

Corridors

Corridors in the forms of hedgerows, fencerows, or headlands allow for the movement of wildlife from one cover type to another. Large open areas are usually avoided by wildlife.

Hedgerows (rows of hedges) can be planted by machine or by hand. They should be planted in strips about six feet wide. Hedge rose, peashrub, and honeysuckle are examples of plant species that would make excellent hedgerows.

Fencerows (uncultivated ground) will develop naturally between fields (usually along property lines) and can be maintained by cutting back larger trees to allow shrub development.

Headlands are grassy strips at the end of cultivated fields. Headlands 15 to 20 feet wide can be established by direct seeding. Ground nesting birds (e.g., bobolink, meadowlark, and song and field sparrows) nest and feed in them.

Use of Established Wetlands

Wetlands provide a water source for wildlife in the surrounding area, as well as food and cover for a variety of other birds and mammals. Waterfowl use wetlands for nesting and brood rearing. Marsh birds and songbirds use wetlands for feeding and nesting areas as well as for cover during spring and fall migration. Mammals, including fox, mink, and raccoon, feed in wetland areas. Corridor plantings and tree/shrub buffer zones around already-established wetland areas make them accessible to wildlife in an agricultural setting.

Spatial Considerations

A plan to establish a desirable mixture of habitat components that will provide the greatest diversity possible is important to enhancing an agricultural operation for wildlife. The above suggestions are all aimed at creating more edge (areas where two or more types of vegetation meet) and adding food and cover sources as well as potential water sources that might otherwise be lacking or inadequate in an agricultural area.

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RECLAMATION FOR WILDLIFE HABITAT

Historically, wildlife management has been viewed as shaping an existing vegetated environment to fulfill requirements for a wildlife species or group of species. In mineland reclamation planning, wildlife management entails designing a large area for a variety of wildlife species where parts of the area may be barren. Wildlife habitat types developed on a mine site would range from grassland to forest land depending on specific management objectives. From barren ground, the natural succession process develops the land from a grassland into a forest. Altering the natural succession process is a major aspect of habitat management in developing a wildlife management program for a reclamation operation. Some questions that should be asked concerning reclamation for wildlife habitat on mining lands are:

1. What plants can survive on the land to be reclaimed?
2. What species of wildlife use these plants for food and cover?
3. Are these plants available? If so, from whom?
4. What planting design would provide proper habitat for wildlife?
5. What are the specific requirements of the wildlife on the site?

Habitat diversity, through a variety of plants and spatial arrangements, is the key to establishing wildlife habitat. Sites can be diversified using various planting techniques, mowing and controlled burning operations, creation and maintenance of wetland areas and forest openings, and other manipulation techniques. One other method of developing habitat diversity is the use of small barren areas. These barren areas should be scattered throughout the site and should never be large enough to discourage the presence of wildlife.

For the purposes of this manual, the goal of wildlife management is to emphasize reclamation practices that provide the habitat components required by wildlife species indigenous to the surrounding area. This section aids the land manager in choosing the wildlife management alternatives best suited to the reclamation plan.

All Upper Midwest wildlife species cannot be considered in reclamation planning because their respective habitat requirements cannot be immediately provided by a newly-reclaimed site. Some of the species discussed in this manual may be more common than others in some parts of the Upper Midwest. In this manual, primary consideration is given to wildlife species that can be supported by habitats developed in the early stages of reclamation or by combinations of reclaimed mineland and adjacent undisturbed land. More well-established habitats are beyond the scope of this manual. Information about long-term wildlife management theories and practices can be found in the references listed at the end of this section.

MANAGEMENT ALTERNATIVES

Management for wildlife generally emphasizes the development and maintenance of habitat for indigenous wildlife species that thrive in the newly-created habitat. Basically, two management alternatives are possible. The land manager may choose to concentrate on one species or group of species (featured species) or on a plan favoring diversity (species richness). Species indigenous to the mine area and adjacent land will use the site to some degree even without reclamation. As revegetation by natural succession progresses, a constantly changing variety of wildlife species will inhabit the area. For the purposes of this manual, planning for species richness will be emphasized as it is usually not possible to focus reclamation efforts on one wildlife species during initial reclamation stages.

An exception is the featured species management program being conducted by White Pine Copper Division of Copper Range Company, White Pine, Michigan. White Pine has developed its clay borrow pits and surrounding land into feeding and nesting habitat for the Canada goose. White Pine has a resident nesting population as well as large flocks of snow, blue, and Canada geese stopping over on their annual southward migrations. More detailed information on wetland development can be obtained from the company.

A good example of management for species richness has been provided by Erie Mining Co., Hoyt Lakes, Minnesota, where waterfowl habitat has been developed in and around their tailing basin. The company planted barley and millet along with other grasses in tailing basins, providing excellent duck and goose feeding areas. An alfalfa and sweet clover mix was planted further away from the water on the tailing basin interiors to provide nesting cover for ducks. As the vegetation became established, other wildlife, including wolves, fox, white-tailed deer, raptors, and a variety of songbirds began to use the area. Further information on the work at Erie Mining Co. can be obtained directly from the company.

A second example of reclamation for diverse wildlife in reclaimed iron ore tailing basins has been provided by Cleveland Cliffs Iron, Ishpeming, Michigan, where grasses and legumes were used to stabilize tailing basins. Woody vegetation was also planted in several areas around the basins. In a study of the area, company personnel sighted over 20 species of breeding birds and mammals. This study illustrates the potential of reclaimed mined lands for wildlife. Further information on this study can be obtained from Cleveland Cliffs Iron or from Michigan Technological University's Forestry Department.

CONSIDERATIONS IN THE DEVELOPMENT OF WILDLIFE HABITAT

Basic Habitat Requirements

The habitat components essential for survival and success of wildlife populations are food, cover, water, and space.

The availability of staple foods is a critical problem in the support of wildlife populations. Wildlife diets change with the seasons as the availability of food and needs of the species vary. It is important that winter food be available to resident species and that excessively large populations do not deplete the food supply

Plants provide different types of cover for given wildlife species. Different types or stages of plant development provide brooding, nesting, and escape cover as well as shelter and thermal cover.

Water requirements are met in different ways for different wildlife species. Although most species require free water in the form of streams, ponds, lakes, etc., some species are able to obtain needed water from plants or dew.

Space is an important component of wildlife habitat and varies according to habitat quality and species needs. It is less easily quantified than food, cover, and water and can best be expressed as the "elbow room" a species needs to survive without social stress. Tolerance to crowding varies with species and season.

Each species of wildlife requires or prefers the presence of different types of food, water, cover, and space in its habitat. Because it is impossible to generalize about these requirements, Appendix F discusses the specific requirements of some of the wildlife species most likely to inhabit the Upper Midwest, including white-tailed deer, ruffed grouse, woodcock, coyote, sharp-tailed grouse, red fox, meadow vole, muskrat, mallard, and Canada goose.

Habitat Types

There are four general categories of wildlife habitat which could be developed on a mine site: grassland, brushland, forest, and wetland. These habitat types can be developed individually or in combination with one another. Each habitat type fills the needs of a specific wildlife community. In this manual, these wildlife communities are identified by the two or three species most commonly associated with the habitat described.

The grassland habitat type is usually the initial vegetal cover whether the area is seeded naturally or artificially. It is characterized by herbaceous vegetation, primarily grasses and legumes. Table 5 lists those herbaceous species preferred by wildlife and how they are used. The red fox - meadow vole community is characteristic of this habitat.

Brushland habitat is often a transition between grassland and a forest or a surrounding wetland area. It is characterized by species such as aspen and birch saplings, willow, cherry, alder, hazel, and dogwood. The brushland habitat is the second successional stage when an area is naturally revegetated. Table 6 lists woody

Table 5. Herbaceous Plants Useful to Wildlife

Plant	Wildlife Species						
	Deer	Coyote	Sharp-tail	Red Fox	Meadow Vole	Mallard	Canada Goose
Grasses							
Creeping foxtail	H	C	CF	C	CF	CF	CH
Buckwheat	H	C	CFH	C	CF	CF	HF
Red top	H	C		C	CF	CF	H
Oats	H	C	CF	C	CF	CF	HF
Annual rye	H	C	CFH	CH	CF	C	CH
Perennial rye	H	C	CFH	CH	CF	C	CH
Millet	H	C		C	CF	CF	HF
Reed canary grass	H	C		C	CF	C	C
Timothy	H	C	CFH	CH	CF	C	H
Wheat	H	C	CFH	C	CF	CF	HF
Legumes							
Birdsfoot trefoil	H	C	HF		CF	C	
Alfalfa	H	C	CH	C	CF	C	H
Sweet Clover	H	C	CH	C	CF	C	H
Alsike clover	H	C	CH		CF	C	H
Red clover	H	C	CH		CF	C	H
White clover	H	C	CH		CF	C	H

C: Cover
H: Herbage
F: Fruits and Seeds

Sources:

U.S. Soil Conservation Service, Miscellaneous Fact Sheets
Rafaill and Fogel (1978)

Table 6. Woody Plants
Useful to Wildlife

Plant	Wildlife Species					
	Deer	Ruffed Grouse	Woodcock	Coyote	Sharptail	Red Fox
Trees						
Northern white cedar	CB			C		C
White spruce	C			C		C
Jack pine	C					
Red maple	B					
Sugar maple	B					
Russian olive	B	HF		C	CHF	C
Green ash	B					
Crabapple	BF	HF		F	CHF	F
Paper birch	B	CHF	C		CH	
Quaking aspen	B	CHF	C		CH	
Mountain ash	B	HF			CHF	
Hybrid poplar	B	HF			CH	
Shrubs						
Gray dogwood	CB	CHF	C	C	C	C
Red-osier dogwood	CB	CHF	C	C	C	C
Thornapple	CBF	CHF	C	F	CHF	CF
Tartarian honeysuckle	B	CHF		C	CHF	C
Smooth sumac	B	CHF		C	CHF	C
Hedge rose	B	CHF	C	CF	CHF	CF
Arrowwood	B	CHF		C	CHF	C
Highbush cranberry	B	CHF		CF	CHF	CF
Siberian peashrub	B	CHF		C	CHF	C
Serviceberry	B	CHF		C	CH	C
Alder	C	CHF	C	C		C
Hazel	CB	CHF		C	CHF	C
Woodvine	B	CH		C		C
Willow	C	CHF	C	C	CH	C

C:	Cover
B:	Browse
H:	Herbage
F:	Fruits and Seeds

Sources:

U.S. Soil Conservation Service, Miscellaneous Fact Sheets
Rafaill and Vogel (1978)

plant species preferred by wildlife. The coyote - sharp-tailed grouse community is common in this habitat.

Four general forest types could be included in a forest habitat in the Upper Midwest. They are the aspen/birch forest, an early successional stage, which could develop into a maple/basswood, spruce/fir, or spruce/balsam forest over a longer period of time. These forest types provide different wildlife habitats for different numbers and kinds of species. Because this manual focuses on the early stages of the revegetation process, only the aspen/birch forest is considered in detail. Information on the other forest habitat types can be obtained from the suggested references at the end of this section. The white-tailed deer - ruffed grouse - woodcock community is usually associated with aspen/birch forest habitat.

A combination of the three basic habitats described above develops over time if the land area revegetates naturally. The plant species present depend on adjacent vegetation.

The wetland habitat is usually a transition between terrestrial and aquatic systems. Wetlands can range from seasonally-flooded basins to permanent marshes, swamps, and bogs. This habitat is characterized by a wide variety of plant species that require saturated or near-saturated soil conditions. Willow, alder, bulrush, sedge, cattail, pondweed, and smartweed are examples. Wetlands provide the most diverse habitat for the greatest variety of wildlife species.

Wetlands development warrants special consideration in the context of mineland reclamation in the Upper Midwest for a variety of reasons; not the least of which is that the northern portions of Michigan, Minnesota, and Wisconsin are composed largely of low-lying areas. Once disturbed by mining, many of these areas would become wetlands on their own if left alone. Wetlands can function as ground and surface water storage areas, flood control areas, firebreaks, and timber production areas. They can also produce bait minnows, marsh hay, wild rice, blueberries, cranberries, and peat moss. The value of wetlands as wildlife areas has already been mentioned.

Given that wetland areas are slowly disappearing throughout the U.S., reclamation of minelands for that purpose becomes especially beneficial. Appendix G lists plant species that can be used to produce wetlands attractive to wildlife in the Upper Midwest.

EXAMPLES OF WILDLIFE HABITAT MANAGEMENT

Basically, the two methods of wildlife habitat management are: (1) natural and (2) artificial. Development of wildlife habitat through artificial management in many cases will alter the natural succession process to provide the vegetal cover type desired for a certain habitat type. In managing an area for wildlife, combinations of grassland, brushland, forest, and wetland habitat types could well be part of the overall plan. The key is integrating the various habitat types with each other and with surrounding areas, always keeping in mind that habitats change with time unless they are artificially controlled. The planning and management process involves making an inventory of the site and a map of the area to show existing habitat types as well as adjacent land use. Given that information, wildlife species likely to inhabit the site can be determined.

The time required to develop an area for wildlife habitat depends on the existing vegetal cover in the area. For example, barren ground will require much more time to develop than an area that already has plant cover. The wildlife area must also be able to provide food and cover during each of the seasons.

Maintaining wildlife habitat requires a continuing management program. Existing land cover can be manipulated through techniques such as planting, plant removal, dredging, burning, mowing, chemical treatment, intercepting runoff, and treatment interval variations.

The management program should be evaluated periodically to determine if the applied management techniques are accomplishing program objectives. The intervals at which evaluations are made depend on a number of factors. Vegetation establishment is a slow process, and consequently evaluations of its progress may extend over very long periods of time. Depending on the prescribed management activity and the specific management techniques recommended, evaluations may be needed annually at first and later at progressively greater intervals. Cost analysis of the applied techniques is complicated by the length of time which may have elapsed between application and achievement of the desired objective.

The following examples of wildlife communities are characteristic of the four major habitat types (grassland, brushland, forest, wetland). The accompanying graphics illustrate how these habitat types might be managed for the appropriate wildlife communities. Included in the discussion are other wildlife species that might also be found in the same habitat. More specific information about the development of wildlife habitat for particular wildlife species can be found in Appendix F or in a series of information sheets developed for that purpose by the U.S. Department of Agriculture, Soil Conservation Service.

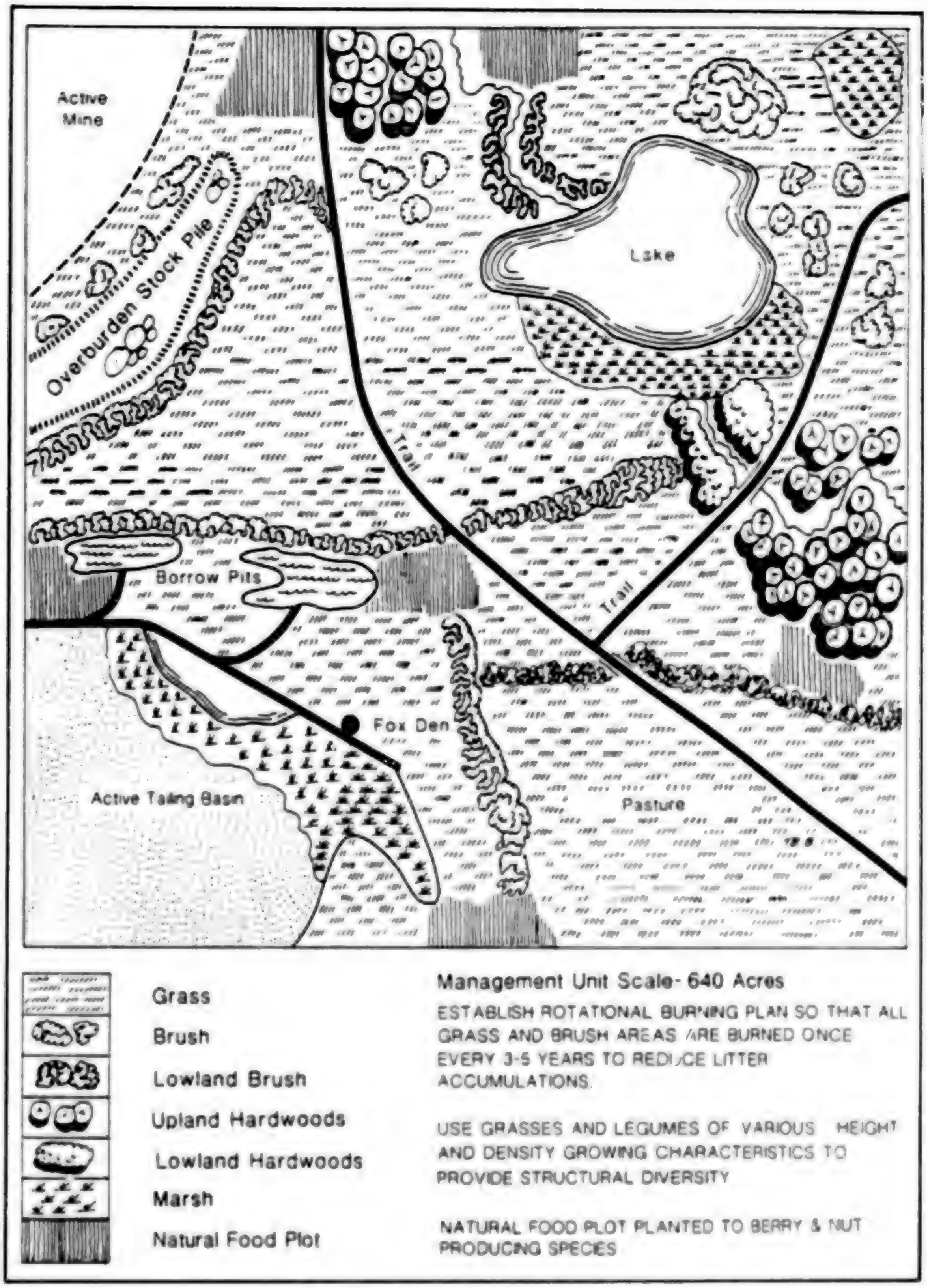
Red Fox - Meadow Vole (Grassland)

The meadow vole is a food source for numerous predators. Management for the meadow vole would be useful in areas where pioneer vegetation is being established and where fur-bearing predators are desired. Hawks and owls would also respond to increased meadow vole populations, although too many meadow voles can cause damage to farm crops, orchards, and forest plantations. Large areas of grasses and grass-like species provide the best habitat.

The red fox is a common visitor to newly-vegetated areas on mine sites. It hunts for small mammals and might use the area as a denning site. The presence of red fox provides excellent opportunities for sport hunting and trapping. The red fox generally prefers transition zones between vegetation types, but it has successfully inhabited tailing basins.

Other species found in this habitat include badger, woodchuck, least weasel, meadow jumping mouse, American kestrel, red-tailed hawk, bobolink, meadowlark, and eastern bluebird.

Figure 7 illustrates a planting design for a grassland habitat.



Management Unit Scale- 640 Acres

ESTABLISH ROTATIONAL BURNING PLAN SO THAT ALL GRASS AND BRUSH AREAS ARE BURNED ONCE EVERY 3-5 YEARS TO REDUCE LITTER ACCUMULATIONS.

USE GRASSES AND LEGUMES OF VARIOUS HEIGHT AND DENSITY GROWING CHARACTERISTICS TO PROVIDE STRUCTURAL DIVERSITY

NATURAL FOOD PLOT PLANTED TO BERRY & NUT PRODUCING SPECIES

Figure 7. Grassland wildlife management.

Coyote - Sharp-Tailed Grouse (Brushland)

Management considerations for these game species require a forest transition type of habitat. It would consist of scattered openings in forest areas with 40-acre blocks of sparse grasses and scattered patches of heavy grass and low brush. It would also include clumps of sapling hardwoods and tall woody shrubs bordering these areas.

Other species benefiting from this management practice would include skunk, badger, least weasel, woodcock, eastern bluebird, gray catbird, brown thrasher, eastern kingbird, and bobolink. Figure 8 illustrates a possible planting design for brushland wildlife management.

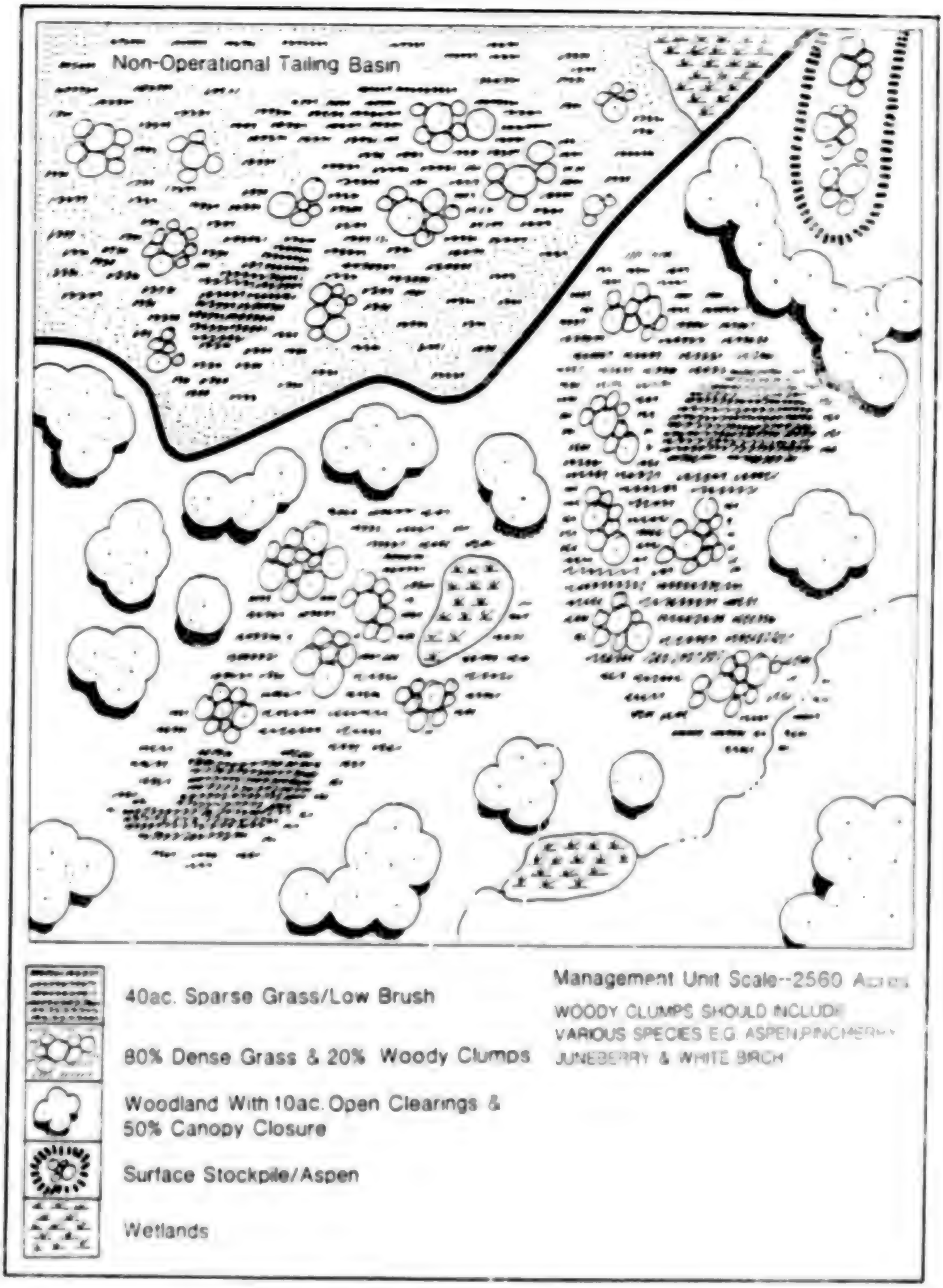

Non-Operational Tailing Basin
40ac. Sparse Grass/Low Brush
80% Dense Grass & 20% Woody Clumps
Woodland With 10ac. Open Clearings & 50% Canopy Closure
Surface Stockpile/Aspen
Wetlands
Management Unit Scale--2560 Acres
WOODY CLUMPS SHOULD INCLUDE VARIOUS SPECIES E.G. ASPEN,PINCHERRY JUNEBERRY & WHITE BIRCH

Figure 8. Brushland wildlife management.

White-Tailed Deer - Ruffed Grouse - Woodcock (Forest)

Management considerations for these game species would require large blocks of land containing various age classes of hardwood trees, primarily aspen. Forty-acre blocks would be the maximum management units and 2.5-acre blocks the minimum management units. Rotational harvesting is recommended to ensure varying forest age classes.

Woodcock habitat would be enhanced by maintaining any wetland areas in this management unit and by providing thickets and hedgerows around grassy openings for "singing grounds" and nesting cover.

Other species that do well in this habitat are bobcat, weasel, goshawk, woodpeckers, and a variety of songbirds. Figure 9 illustrates a possible planting design for forest wildlife management.

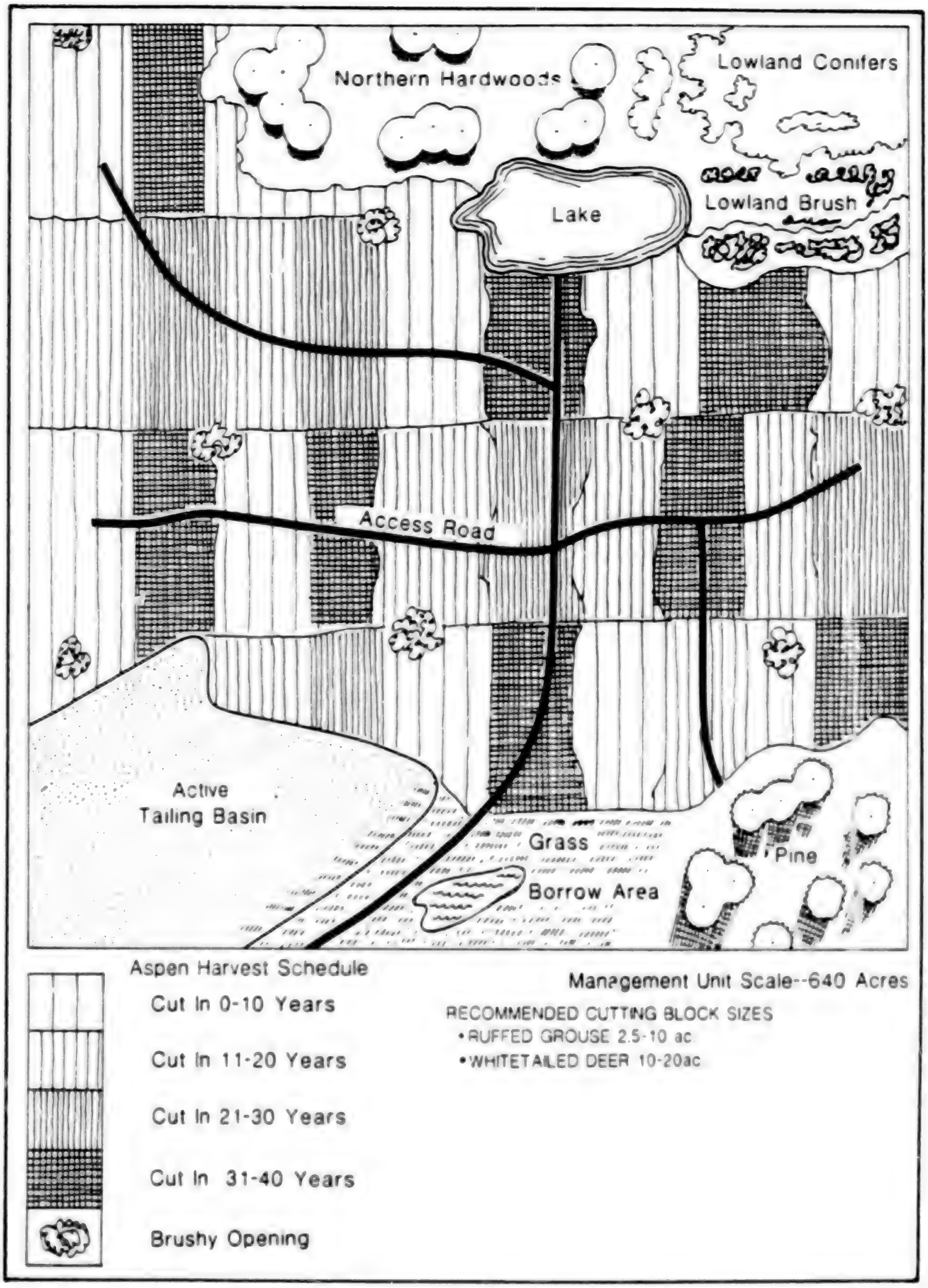


Figure 9. Aspen forest wildlife management.

Furbearers - Waterfowl (Wetland)

The muskrat, which provides recreational and commercial trapping opportunities, is valuable because it creates openings in solid stands of emergent aquatic plants to improve habitat for waterfowl. The muskrat requires permanent water and vegetative cover for constructing lodges. Such an area would also provide escape for the muskrat and waterfowl. It should be noted that the muskrat's burrowing ability could create dike stability problems.

Mallards are surface-feeding ducks and inhabit most small ponds with adequate food and cover. Similarly, blue-winged teal and wood ducks are surface feeders and would also use shallow ponds for feeding and grassy shoreline for nesting. The wood duck would require tree cavities or nest boxes for nesting.

The Canada goose is a prized game bird. It is tolerant of man and responds exceptionally well to habitat improvement practices. Canada geese seek large bodies of water during the hunting season and fly to nearby grain fields and large grassy areas.

Some wetland management practices which could be used include:

1. Maintain a water depth of less than three feet in ponds to promote food-producing plants and allow dabbling ducks to reach bottom foods.

2. Provide grassy border around ponds for nesting and escape cover.

3. Develop islands in deeper water for waterfowl loafing areas and potential goose nesting sites.

4. Use rock piles, logs, or wood rafts for loafing sites in shallow water areas of ponds.

5. Construct predator-proof wood duck nest boxes near wetlands.

Wetland management practices would also benefit raccoons, skunk, mink, wigeons, the great blue heron, and a variety of marsh birds and songbirds.

Figure 10 illustrates a possible management design for a wetland habitat.

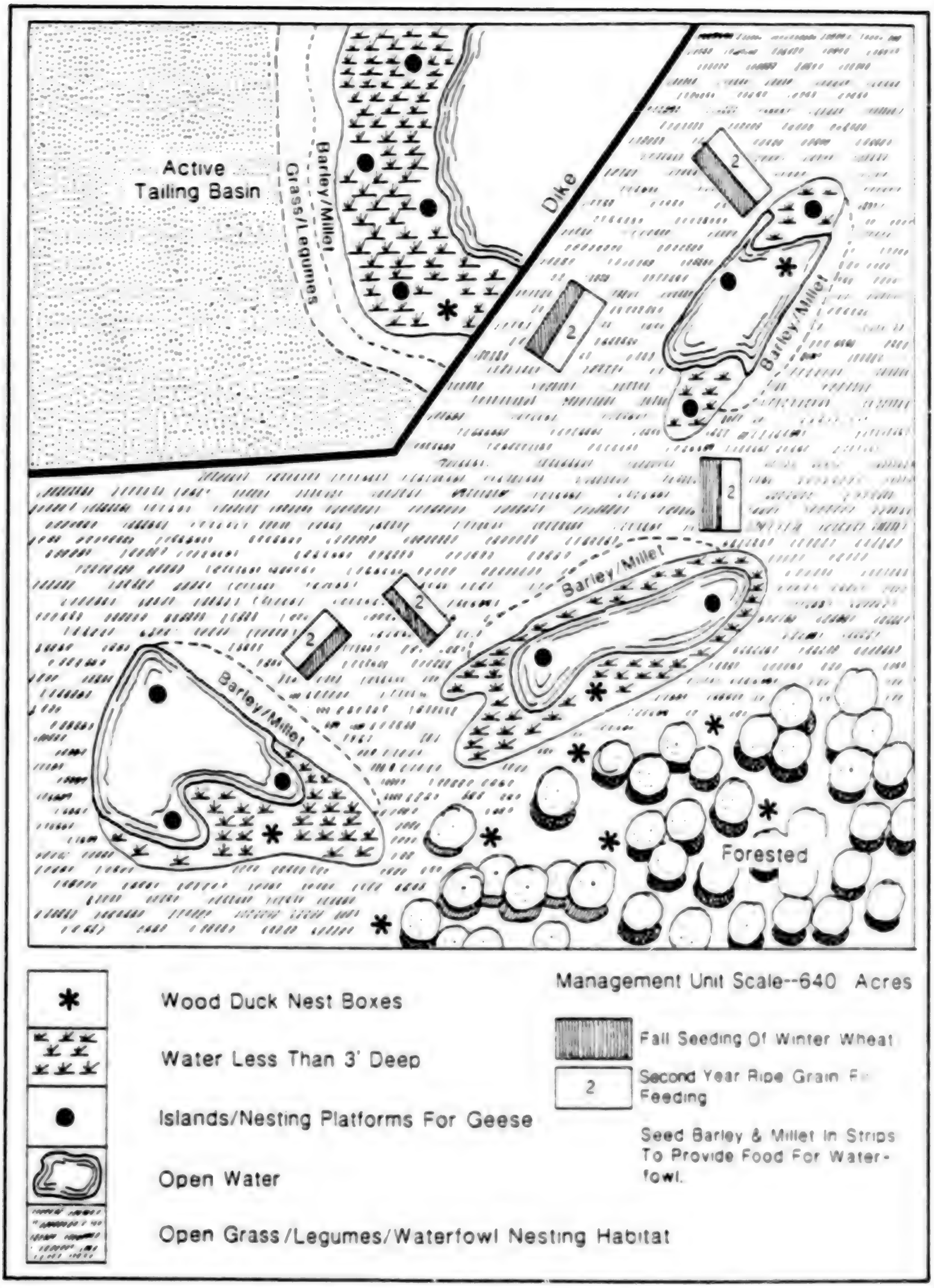

Active Tailing Basin
Barley/Millet
Grass/Legumes
Dike
2
Barley/Millet
Barley/Millet
Barley/Millet
Forested
Wood Duck Nest Boxes
Water Less Than 3' Deep
Islands/Nesting Platforms For Geese
Open Water
Open Grass/Legumes/Waterfowl Nesting Habitat
Management Unit Scale--640 Acres
Fall Seeding Of Winter Wheat
Second Year Ripe Grain For Feeding
Seed Barley & Millet In Strips To Provide Food For Water-fowl.

Figure 10. Wetland wildlife management.

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RECLAMATION FOR FISHERIES

A review of past and present fisheries management in the hard rock mining operations of the Upper Midwest yielded too little information to allow detailed assessment of its potential for this region. On occasion, the Minnesota Department of Natural Resources has stocked fish in abandoned iron mines throughout the Iron Range area of northern Minnesota; however, the success of these efforts has not been clearly established because the extreme depth of these pits has made field sampling of the fish populations very difficult. Since 1972, only one inactive mine pit, the Portsmouth, on the Cuyuna Range has been actively managed for trout through yearly maintenance stocking by the State of Minnesota. The Minnesota DNR has also successfully rehabilitated the Kinney and the McNiven Pits on the Mesabi Range as trout lakes. The Tioga Pit on the Mesabi Range has recently been stocked with trout, though it is too early to tell if that effort has been successful.

In Michigan's Upper Peninsula, Lake Angeline (a natural lake) was drained and mined for iron. After the lake was refilled, the Michigan DNR stocked it with a tiger-muskie population which has since continued to survive. Other attempts to establish fisheries in Michigan's hard rock mining areas have generally been unsuccessful. Oxygen depletion during winter and lack of spawning and food-producing habitat have been the major problems.

According to the Wisconsin DNR, fisheries development has not been attempted in Wisconsin's hard rock mining areas. In Wisconsin's soft rock mining areas, successful fishery programs have been established.

A few of the mining companies in the Upper Midwest have introduced fish to their abandoned mine pits, ditches, or tailing ponds without a defined study objective or formal follow-up. Reserve Mining Company, a taconite producing operation, has conducted research into the effect of taconite tailing on both trout and macro-invertebrate food organisms. The bioassay-type studies involved exposing various life stages of rainbow and lake trout to various concentrations of taconite tailing. Reserve's 34-month study of the growth and development of rainbow trout in their pilot plant tailing clarification basin concluded that the tailing in that basin did not cause any physical or chemical damage to the various life history stages of the trout.

Because experience with the establishment of fisheries in hard rock mining areas of the Upper Midwest is still in the pioneer stage, it is impossible to prescribe simple formulas for future mineland reclamation for fisheries. This manual can only provide information relating to fisheries establishment in general. This section first discusses the types of minelands that might be suitable for fisheries development as well as the associated constraints. Then, types of fisheries are introduced. A general discussion of the environmental factors crucial to fisheries development concludes the section.

TYPES OF MINELANDS SUITED FOR FISHERY DEVELOPMENT

There is potential for fishery development in Upper Midwest mining operations insofar as various types and sizes of water bodies are the remnants of abandoned open-pit operations. Potential fishery sites include abandoned mine pits that have filled with water after mining operations have been completed, the diversion ditches used in routing water through the mining operation, borrow pits, and tailing clarification ponds where waste material and water are discharged and water is recycled. Each area could sustain certain species of fish; however, each poses a variety of problems which would have to be solved first.

The potential for fisheries development in Upper Midwest mining areas is currently severely inhibited by the extreme depth and steep slopes of abandoned pits. In the shallow ditches and tailing ponds, winterkill conditions could be a problem. In addition, the virtually sterile substrate does not promote colonization by biological communities. Some mine operators are also concerned about interruption of mining and about the potential for liability problems resulting from accidents involving the public. Consequently, fisheries development is currently a relatively unattractive reclamation option.

There is, however, better potential for the future. It is possible that future in-mine waste disposal would result in much shallower abandoned pits. This, in turn, would make it easier and more practical to grade steep pit slopes to provide for better shoreline conditions. The combination of these two operations would provide conditions similar to other lakes in the area, though substrate quality might still be a problem.

POTENTIAL CONSTRAINTS

There are many potential constraints in the development of a fishery which are not a result of the chemical or biological limitations of the water body. Specifically, changing water levels, costs, availability of fish, and public safety can present problems in the development of fisheries habitat.

Changing water levels are of major importance. Water level drawdown for operational reasons can have significant impacts on fisheries during periods of peak stress, (e.g., egg hatching, early fish development, or before mass emergence of the insect community serving as the major food source). For example, the dewatering of adjacent mine pits not associated with the pit managed for fisheries could substantially lower the water level in the managed pit, and thus reduce potential productivity of the basin. Plant shut-downs will impact the fisheries in diversion ditches and tailing ponds where the lack of flowing water or water lost through seepage and evaporation could significantly reduce the habitat.

A second major constraint is cost. Little specific data are available on the costs associated with fisheries development; however, habitat studies, fish stocking, and evaluation of the stocking are expensive. Habitat surveys, associated testing costs, as well as testing for site selection can also be expensive depending on scope. Proper program evaluation also requires funding.

Sometimes, even if unlimited funds are available for the purchase of fish, the species most suitable to the proposed habitat may not be available in sufficient quantities. In these cases, less desirable fish species would have to be substituted.

Development of any water resource involves a risk to the public. Abandoned mining operations have not generally been modified for public use, contributing to higher accident risks. Steep drop-offs near shore, limited or difficult access, and close proximity to active mining sites are concerns which need to be addressed in the long-range planning of reclamation for fisheries to be used by the public.

TYPES OF FISHERIES

Fish are grouped into three major categories -- cold, cool, and warm water. These categories are not rigorously defined. Representative cold water fish might be the trout and chars, warm water fish might be the bass and panfish (bluegills, sunfish, etc.), and cool water fish are represented by northern pike, walleye, and yellow perch. Species such as the cisco and panfish can be used as a forage fish population for predator species such as trout and bass. Other forage fish, including minnows, chubs, darters, suckers, etc., can also be used if a forage fish population must be developed. Northern pike are able to survive in most habitats provided adequate vegetation is present. Fish species used should be indigenous to the area to be stocked. A partial listing of fish species common to the Upper Midwest is presented in Appendix H.

Mixing cold and warm water fish with similar habitat needs is not recommended. The low productivity associated with a mining environment and competition between many species could hamper the success of the project if more than one principal gamefish were to be stocked.

ENVIRONMENTAL FACTORS

The environmental factors affecting the success of fisheries development must be evaluated prior to introducing fish species to the water body. Knowledge of the habitat is crucial to the success of the program. Proper habitat identification will permit using the uniqueness of each water body to good advantage by selecting the fish species that are most likely to thrive in that environment. Habitat evaluation can be subdivided into physical, chemical, and biological factors.

Physical Factors

The physical environment can be defined by its temperature, surface area, substrate, depth, and shoreline.

Temperature. Measurement of temperature profiles during the different seasons is probably the simplest and most important method of assessing the habitat. The more frequent the measurements the better, because fish metabolic activities are closely linked with temperature. The duration of a given temperature level can determine whether a particular fish will reach its next life stage. Temperature is also important in determining distribution of dissolved oxygen. Thermal stratification can effectively seal the different layers of the water, resulting in oxygen depletion in lower water levels. This effectively limits fisheries habitat to the upper water levels. Table 7 shows the temperature requirements for selected fish.

Surface Area. Surface area gives an indication of the potential for water mixing, oxygen replenishment, solar radiation, and the solar energy available for primary production by algae. Wind forces direct much of the oxygen and temperature distribution patterns in the water body. The larger the surface area, the greater the potential for circulation. Solar radiation is the principal source of energy in a water body. The amount of surface area available to solar penetration, the greater the potential temperature ranges. In addition to changing temperature, solar energy is used by algae in the production of biomass. The larger the surface area, the greater the potential for biomass production.

Substrate. The substrate of a water body is composed of many types of material. Different fish species need different substrate types. Material distribution in the substrate can be used to classify water bodies for different fish species. The following table shows the relationship of the different bottom types to the different fish groups.

Bottom Type %	Trout	Walleye	Bass	Panfish
Bedrock Boulder	30-100	--	--	--
Gravel Sand	20	90	75	75
Organic	10	10	25	25

Depth. Depth profiles obtained from sonar mapping provide subsurface habitat information. The different fish species usually prefer differing depth ranges. Fluctuating water levels represent a potential constraint if depth is not sufficient.

Shoreline. Shoreline assessments should consider the length and configuration of the shoreline, the shallow water substrate, and the nature of the shore bank. Shoreline length and configuration can increase the diversity of habitat for spawning. For example, if a water body has wind-swept shores for one species and protection for another, coexistence of two ordinarily incompatible species may be possible. The length and configuration could also alter the percentage of shoreline area less than 15 feet deep. Substrate along the shoreline provides spawning habitat, so its diversity should be assessed. The nature of the shoreline bank material can provide needed substrate, but susceptibility to erosion might also result in the covering of an active spawning bed.

The percentage of shoreline (lake area less than 15 feet deep) has been correlated with different fish species. The percentage of shoreline required by the major fish groups is presented in the following table.

	Trout	Walleye	Bass	Panfish
% Shoreline	15-20	15-35	25-50	25-50

Table 7. Temperature Requirements of Selected Fish

Fish	Preferred Range°C	Spawning Period°C	Maximum °C
Trout			
Lake trout	7-14	10-19	21
Rainbow trout	13-21	10-15	24
Brook trout	9-17	5-11	20
Brown trout	18-24	7-9	--
Cisco (tullibee)	--	3-5	26
Bass	20-28	12-18	32
Largemouth bass	26-28	12-18	32
Smallmouth bass	20-21	12-18	27
Pike			
Northern pike	19-20	4-11	28
Perch	13-24	6-12	30
Walleye	13-18	6-11	24
Sauger	18-19	6-11	--
Yellow perch	21-24	9-12	30
Panfish	--	12-28	--
Longear sunfish	--	23-35	--
Green sunfish	--	20-28	--
Pumpkinseed	--	20-28	28-30
Bluegill	--	12-25	--

Sources:

Scott, Crossman (1973)
Scidmore (1970)
Kendall (1978)

Table 8 describes the spawning grounds preferred by several fish species.

Chemical Factors

The primary elements of the chemical environment are dissolved oxygen, background nutrient levels (such as nitrogen, phosphorus, sulfate, potassium, and carbonates), alkalinity, specific conductance, and pH. These provide most of the general indications of nutrient availability. The presence of potentially toxic substances should also be investigated, including heavy metals and chemicals which could be discharged during the mining process.

Dissolved oxygen levels are as important as temperature for fish survival. Tolerances vary among the different fish species and within a given species' life cycle. Age, nutritional state, and level of activity alter the dissolved oxygen necessary to avoid stress. The following briefly summarizes species requirements.

Group	Minimum Level
Trout	6 mg/l, except during spawning when 7 mg/l is recommended in the overlying water. A minimum of 5 mg/l within the gravel of the spawning beds is recommended.
Walleye, Bass, Panfish, Pike	5 mg/l on the average in the overlying water throughout the year.

In some cases, dissolved oxygen levels below the thermocline (a boundary layer of rapid temperature change) are important. A well-developed thermocline effectively blocks oxygen replacement in the lake bottom, and the resulting oxygen depletion reduces available fish habitat and forces the fish into warmer surface waters.

Lake Type	Dissolved Oxygen Below Thermocline
Trout	5.0 mg/l
Walleye/Perch	May be Absent
Bass	May be Absent
Panfish	Usually Absent

A water body's biological productivity is directly related to the water's chemical characteristics. Alkalinity and phosphorus are two commonly-measured parameters. Other parameters (e.g., nitrogen derivatives), other ions (e.g., potassium, sodium, sulfate, magnesium, calcium), heavy metals, and hydrocarbon derivatives can also be analyzed to assess the water's potential to enhance a fisheries habitat.

Generally, the more alkaline a water body is, the more biologically productive it will be. Alkalinity is measured by analyzing levels of calcium and magnesium carbonates. The carbonates are derived either from the lime within the watershed or as a result of algal metabolism, or both.

Table 8. Spawning Grounds

Fish	Spawning Substrate	Spawning Depth Ft.
Trout	fine to coarse gravel, generally in streams	shallow
Smallmouth bass	sandy, gravel, or rocky bottom	2-20
Largemouth bass	gravelly sand to marl and soft mud in vegetation	1-4
Walleye, Sauger	rocky areas in white water, coarse gravel shoals in lakes	---
Northern pike	rooted vegetation, egg mass adheres to vegetation on lake shores and rivers	<0.5
Yellow perch	rooted vegetation, submerged brush, or fallen trees, sometimes sand or gravel, egg mass adheres to vegetation on lake shores or stream bottoms	---
Panfish:		
Longear sunfish	gravel, sand or hard mud	1
Green sunfish	sunlit areas, sheltered by rocks, logs, vegetation clumps	1
Pumpkinseed	among submerged vegetation	0.5-1
Bluegill	clear areas down to firm substrate	2.5

Source: Scidmore (1970)

Phosphorus is the element that most often limits biological production in fresh waters. The amount of phosphorus in the water body to some extent determines the biological production that can be expected.

Estimates for alkalinity and total phosphorus levels associated with specific types of fisheries are presented in the following table.

Fish	Alkalinity, mg/l	Phosphorus, mg/l
Trout	40	.020
Walleye	40	.025
Bass, Panfish	100	.005

Biological Factors

The ability of fish to survive in a water body can be predicted by evaluation of the physical and chemical water body characteristics. For the fish to thrive, an adequate food supply must be present. The biological environment provides the fish population's food supply. Indicators of food supply are the aquatic insect life, plant cover, relative abundance of the algae, and smaller forage fish.

Precise evaluation of the biological environment requires trained personnel and laboratory testing; however, on-site observation of the biological environment can provide a general indication of the potential food supply.

Insects. Check densities of various winged insects such as mayfly swarms, midge swarms, and dragonflies. These insects in their immature forms comprise a substantial part of the fish diet. Evaluation can be relative i.e., present, common, abundant. Generally, the more abundant the insect population, the greater the potential food source.

Plants. Submerged and emergent plants provide necessary cover for fish in addition to acting as colonization areas for many fish food organisms. In many mine water bodies, cover may need to be developed (where it does not interfere with mine production activity). (Cover can be provided artificially by using old tires bound together to form submerged reefs or by depositing piles of boulders in scattered areas.) Large-leafed plants provide better cover than the smaller-leafed varieties. In planting shallow water areas, not more than one-third of the area should be colonized because too much vegetation can promote stunting of the panfish population.

Algae. Algae are the base of the food chain for most fish. Algae convert sunlight and nutrient materials into biomass. Some algae are consumed directly by fish; others are first consumed by zooplankton which in turn are eaten by fish. Algal abundance can be determined by testing chlorophyll concentrations (a green pigment of the algae). Chlorophyll tests would have to be conducted in a laboratory with the proper equipment.

Forage Fish. Forage fish generally consist of minnows and the small gamefish that are consumed by larger fish. As fish become larger, most will prey upon smaller fish to meet their needs. The forage fish also provide food for the diving ducks and other wildlife along the shore. To determine the presence of forage fish, look for diving waterfowl and for schools of small fish in shallow areas.

SUGGESTED REFERENCES

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WILDLIFE ENHANCEMENT WORKSHEET

Establishing a desirable mixture of habitat components that will provide the greatest possible diversity is the main objective in enhancing wildlife. Vegetation changes with time; therefore, the quality and quantity of food and cover for wildlife will change resulting in continuously changing wildlife populations.

The following worksheets will aid the reclamation specialist in assessing and improving wildlife habitat potential: 1) a preliminary site reclamation map, 2) a checklist of questions designed to identify potential means of wildlife enhancement, and 3) a final reclamation map incorporating wildlife enhancement into the site reclamation plan. Information to be used in preparing the worksheets can be taken from this manual as well as from the specific data available for the area being reclaimed.

Where environmental studies have preceded reclamation planning, a wealth of site-specific information will be available for detailed planning. In these cases, the reclamation specialist may want to modify the following worksheet process to reflect the appropriate level of detail. On the other hand, some people may only have access to limited site-specific information. In such cases, the reclamation specialist may require outside help to compile the information needed.

STEP 1: PREPARATION OF PRELIMINARY RECLAMATION MAP

Step 1 in the worksheet planning process requires the preparation of a preliminary site reclamation map. This map should show the spatial arrangements of existing and proposed vegetative cover types on the site and adjacent areas. The preliminary reclamation map should include the following:

(1) All areas disturbed by mining operations.

(2) Adjacent undisturbed land showing vegetative cover types.

(3) Vegetative cover types, existing and proposed, on those sites to be reclaimed for selected end uses.

(4) Wildlife species currently using the site as well as type of use, i.e., nesting, feeding, and migrating.

These areas can be delineated by drawing simple lines outlining the necessary information for specific sites on a base map. The preliminary map might also be prepared as an overlay to another map outlining those areas being reclaimed, with appropriate steps and techniques numbered and lettered to allow for easy reference in subsequent steps of the planning process.

STEP 2: USE OF CHECKLIST

Step 2 involves responding to a checklist to identify wildlife enhancement potential of the site by using the preliminary reclamation map developed in Step 1. The questions on the checklist (Exhibit 1) address the basic methods of enhancing any given area for wildlife, including specific questions directed toward enhancing the habitat potential in agricultural and forestry areas. The checklist, which can be modified to reflect site-specific conditions, should also help to resolve conflicts in land use and application of specific enhancement techniques.

The major questions asked in the checklist relate to 1) the characteristics of the various sites being reclaimed, 2) the wildlife using the site, 3) the wildlife enhancement potential of the vegetative cover types, and 4) the modification practices that would enhance wildlife in all areas. Each of these questions is broken down further to help identify specific wildlife enhancement techniques.

As these questions are answered, notations can be made on the base map prepared in Step 1 to enable a complete review of the entire site after completion of Step 2. The final map (prepared in Step 3) will reflect decisions made on the basis of the information provided through use of the checklist.

STEP 3: PREPARATION OF THE FINAL RECLAMATION PLAN MAP

Step 3 requires the preparation of a final reclamation plan map showing the base map plus the information derived from the checklist. This map will clearly show the reclamation plan itself as well as implications for wildlife enhancement. Once the final map is completed, the land manager will be ready to implement the reclamation plan, assuming that problems posed by regulatory, economic, and other external constraints have been solved.

Exhibit 2 is an example of how a land manager might reclaim his mine site using the wildlife enhancement planning process. It illustrates the use of the maps and checklist. The situation described is fictional, but it includes many of the elements a land manager might confront in Upper Midwest mining areas.

EXHIBIT I
CHECKLIST TO IDENTIFY WILDLIFE ENHANCEMENT POTENTIAL

How can proposed wildlife management areas identified in Step I be designed to enhance wildlife? (See p. 41)

A. By developing vegetative cover types:

1. to form windrows or hedgerows to break up large open areas?
2. by planting hedgerows or fence borders between two cover types?
3. on or along old haul roads, powerlines, and pipelines?
4. to diversify cover types proposed on barren areas?
5. to create borders along areas which cannot be vegetated or only temporarily vegetated?

B. Have potential wetland areas been maximized for wildlife?

1. within interiors of inactive tailing basins?
2. in borrow areas with potential impoundment capacities?
3. by impounding water in low areas?

C. By developing artificial structures to further enhance wildlife such as:

1. erecting birdhouses and perches on the site?
2. creating waterfowl impoundments including nesting or loafing facilities?

How can proposed forestry cover types be designed to enhance wildlife? (See p. 29) By:

A. creation of openings in monotypic stands of timber?

B. establishing corridors through monotypic stands of timber by planting other species of woody and herbaceous plants in strips?

C. the use of rotational harvest to provide varying age classes of timber?

D. timing of harvest and size of timber block harvested?

How can proposed agricultural cover types be designed to enhance wildlife? (See p. 37) By:

A. modification of plant species used?

B. delayed mowing of hayland?

C. planting windrows and fencerows to form corridors through large open areas?

D. maintenance of wetlands on agricultural sites?

Is the planned reclamation: (See p. 7)

A. consistent with the surrounding land use and proposed future use of reclaimed mineland?

B. within regulatory requirements?

C. economically practical?

D. consistent with public concerns?

E. outside of areas designated for future mining operations? (permanent reclamation only)

EXHIBIT 2
WORKSHEET EXAMPLE

The following is a fictional example of how a land manager could apply the information in the manual in conjunction with the worksheets in evaluating his reclamation plan for wildlife.

Iron Mining, Inc. is a taconite pellet producing plant operation located in northern Minnesota. The time schedule of the mining plan indicates that both temporary and permanent reclaiming of a portion of the operation is scheduled. In ten years, the following areas will be available for permanent reclamation: (1) tailing basin #1 (300 acres), (2) a borrow area (50 acres), and (3) a surface overburden pile (60 acres). These areas are to be permanently reclaimed according to State regulatory standards. Temporary reclamation is scheduled for a portion of tailing basin #2 due to dust problems.

The company's land holdings are about 10 square miles. This operation is bordered on one side by a municipality and pasture land. The remainder of the site is surrounded by an aspen/birch forest.

Given his knowledge of the site, its environmental constraints, cost, and other factors and wildlife information from this manual, the land manager of this plant has chosen the following reclamation options. He has decided a forestry and wildlife management option could be feasible on the surface overburden to be permanently reclaimed. The top of the overburden pile will be planted with jack pine while the slopes will be developed for wildlife habitat. In tailing basin #1, the manager will develop pasture land. The higher basin elevations, areas periodically flooded, and the dam slopes will be managed for wildlife habitat. The borrow area is suitable for a small pulp (aspen) growing operation, and the pit areas are potentially excellent waterfowl habitat.

The temporary reclamation areas will be vegetated for wildlife where practical. A portion of tailing basin #2 will be planted with grasses and legumes, including grains, to provide some seasonal waterfowl food and resting areas.

The manager then prepares a preliminary reclamation map. After delineating these areas on the map, he works through the worksheet process as follows:

Step 1

The completed preliminary reclamation map is shown in Figure 11. This map shows the vegetative cover types and sizes of the areas being reclaimed as well as the vegetative cover types on adjoining lands. The map also shows the wildlife currently using the site.

Step 2

The manager prepares a checklist to determine how his proposed wildlife management areas can be designed to enhance wildlife.

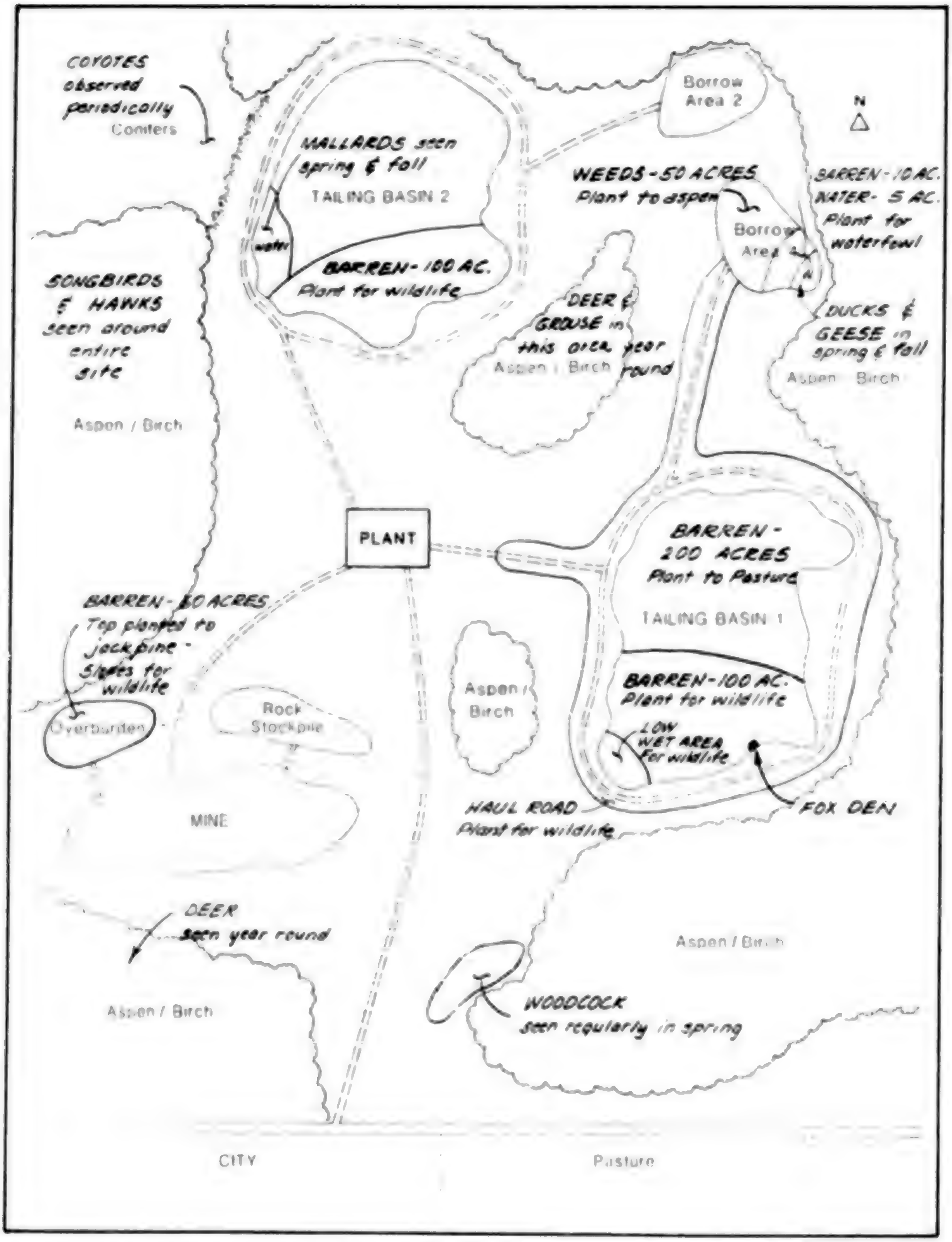
COYOTES observed periodically
Conifers
MALLARDS seen spring & fall
TAILING BASIN 2
water
BARREN - 100 AC. Plant for wildlife
Borrow Area 2
N
WEEDS - 50 ACRES Plant to aspen
BARREN - 10 AC. WATER - 5 AC. Plant for waterfowl
Borrow Area 4
SONGBIRDS & HAWKS seen around entire site
DEER & GROUSE in this area year round
Aspen / Birch
DUCKS & GEESE in spring & fall
Aspen / Birch
Aspen / Birch
PLANT
BARREN - 200 ACRES Plant to Pasture
TAILING BASIN 1
BARREN - 50 ACRES Top planted to jackpine - Slopes for wildlife
BARREN - 100 AC. Plant for wildlife
Aspen / Birch
Overburden
Rock Stockpile
LOW WET AREA for wildlife
HAUL ROAD Plant for wildlife
FOX DEN
MINE
DEER seen year round
Aspen / Birch
WOODCOCK seen regularly in spring
Aspen / Birch
CITY
Pasture

Figure 11. Example of proposed (10-year) reclamation planning map.

A. By developing vegetative cover types:

1. to form windrows, hedgerows, or to break up large open areas.

   Tailing Basin #1 -- windrows will be planted at right angles to prevailing winds to provide food and cover for wildlife, as well as erosion control.

2. by planting hedgerows or fence borders between two cover types.

   Tailing Basin #1 -- shrubs, grasses and legumes will be planted on the slopes bordering the old haul road, and shrubs will be planted along the field border adjoining the wildlife management area.

   Overburden -- shrubs will be planted on slopes adjacent to the proposed forested area.

   Borrow area -- the transition between the existing forest area and proposed wildlife area will be planted with grass and shrubs.

3. on or along old haul roads, powerlines, or pipelines.

   Tailing Basin #1 -- access road to basin will be reclaimed with grasses and legumes, with shrubs planted along the borders.

4. to diversify cover types on barren areas.

   Tailing Basin #1 -- spaced planting of permanent and herbaceous plants to maximize wildlife habitat. All areas within the basin will be planted, and aquatic vegetation will be established where applicable.

   Tailing Basin #2 -- legumes and grasses of different heights will be planted in alternating rows, and barley and millet will be planted closest to the wet areas in the basin.

   Borrow Area -- grasses and grains will be planted around the perimeter of the water areas to provide waterfowl habitat.

5. to create borders along areas which cannot be vegetated or only temporarily vegetated, e.g., rock or stockpiles -- not applicable.

Have potential wetland areas been maximized for wildlife.

A. within interior of inactive tailing basins -- yes.

B. in borrow areas with potential impoundment capacities -- yes.

C. by impounding water in low areas -- not applicable.

By developing artificial structures to further enhance wildlife, such as:

A. erecting birdhouses and perches on the site.

Tailing Basin #1 -- build a series of bluebird houses around the interior of the basin at the higher elevations.

Borrow Area -- woodduck boxes can be placed near the open water area.

B. creating waterfowl impoundments including nesting or loafing facilities -- not applicable.

How can proposed forestry cover types be designed to enhance wildlife? By:

A. creation of openings in monotypic stands of timber -- not applicable.

B. establishing corridors through monotypic stands of timber by planting other species of woody and herbaceous plants in strips.

Surface Overburden -- top of pile will be broken into four 15-acre plots with corridors, shrubs, grasses, and legumes.

C. use of rotational harvest to provide varying age classes of timber.

Borrow Area -- planted with aspen to be harvested in 10-acre blocks to manage for deer habitat. Ten-acre blocks are ideal for deer habitat and are also relatively economical to harvest.

D. timing of harvest and size of timber block harvested.

Surface Overburden -- plant four different age classes of jack pine to provide a good browse source for deer.

How can proposed agricultural cover types be designed to enhance wildlife? By:

A. modification of plant species used.

Tailing Basin #1 -- seed mix will contain a mixture of intermediate wheat grass, smooth brome, perennial ryegrass, red clover, and sweet clover. Alfalfa will be excluded because it causes bloat in cattle.

B. delayed mowing of hayland -- not applicable.

C. planting windrows and fencerows to form corridors through large open areas.

Tailing Basin #1 -- windrows will be planted in conjunction with the adjacent wildlife management area. The species used will be thornapple and hedgerose, which are preferred by deer, ruffed grouse, and songbirds.

D. maintenance of wetlands on agricultural sites.

Tailing Basin #1 -- regulations require draining of potential wetlands on this site.

Is the planned reclamation:

A. consistent with the surrounding land use and proposed future use of reclaimed mineland -- yes.

B. within regulatory requirements -- yes.

C. economically practical -- yes.

D. consistent with public concerns -- yes.

E. outside of areas designated for future mining operations (permanent reclamation only) -- yes.

Step 3 -- Final Reclamation Map

From information indicated on the preliminary map in Step 1 and from the information developed from the checklist in Step 2, a final map was drawn incorporating the potential modifications (Figure 12).

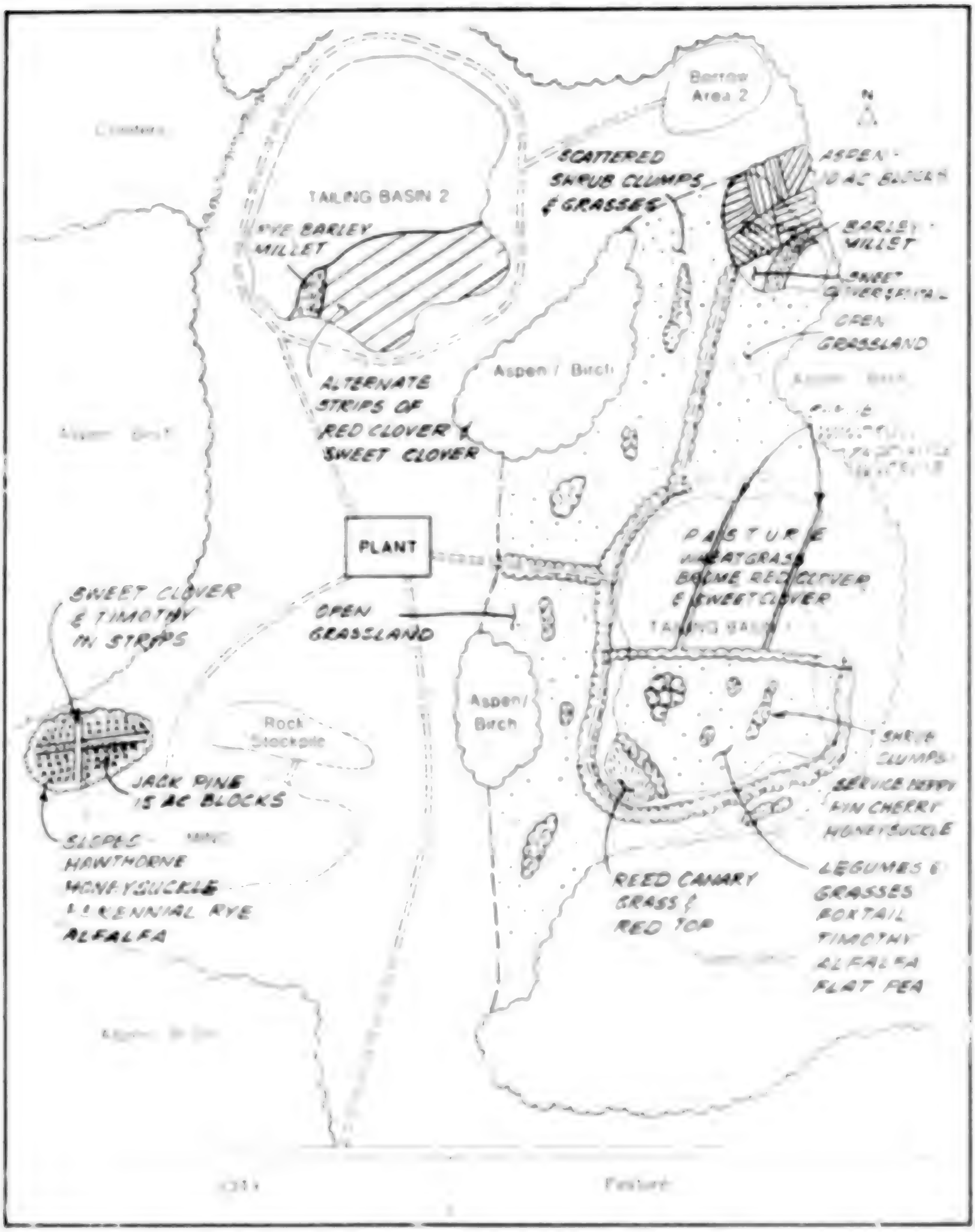

Figure 12. Example of final reclamation map.

APPENDIX A

LOCAL CONSULTING SOURCES

Michigan, Minnesota, and Wisconsin

Public

Forestry

Michigan
Chief, Forestry Division
Department of Natural Resources
Mason Building
Lansing, Michigan 48926
517-373-1275

Minnesota
Director, Division of Forestry
Centennial Building
658 Cedar Street
St. Paul, Minnesota 55155
612-296-4484

Wisconsin
Bureau of Forestry
Department of Natural Resources
Box 450
Madison, Wisconsin 53701
608-266-2621

Fish and Wildlife

U.S. Fish and Wildlife Service
301 Manly Miles Building
1405 South Harrison Road
East Lansing, Michigan 48823
517-337-6614

U.S. Fish and Wildlife Service
538 Federal Building and U.S. Court House
316 North Robert Street
St. Paul, Minnesota 55101
612-725-3502

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APPENDIX A

LOCAL CONSULTING SOURCES

Michigan, Minnesota, and Wisconsin

Public

(Continued)

U.S. Fish and Wildlife Service
University of Wisconsin - Green Bay
Green Bay, Wisconsin 54302
414-465-2682

Michigan Department of Natural Resources
Wildlife Division
P.O. Box 30028
Lansing, Michigan 48909
517-373-1263

Michigan Department of Natural Resources
Fisheries Division
P.O. Box 30028
Lansing, Michigan 48909
517-373-1280

Minnesota Department of Natural Resources
Division of Fish and Wildlife
Centennial Office Building
658 Cedar Street
St. Paul, Minnesota 55101
612-296-2894

Fisheries Section -- 612-296-3325
Wildlife Section -- 612-296-3344

Wisconsin Department of Natural Resources
Bureau of Fish Management
or
Bureau of Wildlife Management
P.O. Box 7921
Madison, Wisconsin 53707
608-266-1877 (for both bureaus)

Soil Conservation Service, U.S. Department of Agriculture

State Conservationist
Soil Conservation Service - East Lansing
Room 101
1405 South Harrison Road
East Lansing, Michigan 48823
517-372-1910

APPENDIX A
LOCAL CONSULTING SOURCES
Michigan, Minnesota, and Wisconsin
Public
(Concluded)

State Conservationist
Soil Conservation Service - St. Paul
200 Federal Building and U.S. Courthouse
316 North Robert Street
St. Paul, Minnesota 55101
612-725-7675

State Conservationist
Soil Conservation Service - Madison
4601 Hammersley Road
Madison, Wisconsin 53711
608-252-5351

Colleges and Universities

Michigan Technological University
Ford Forestry Center
Houghton, Michigan 49931
906-524-6181

University of Wisconsin - Stevens Point
School of Natural Resources
Stevens Point, Wisconsin 54481
715-346-0123

Agricultural Extension Service
240 Coffey Hall
University of Minnesota
St. Paul, Minnesota 55108
612-373-1246

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APPENDIX B

LOCAL CONSULTING SOURCES*

Michigan, Minnesota, and Wisconsin

Private

Anderson, Harold E.
2611 East Sixth Street
Duluth, Minnesota 55812
218-724-7661

Banzhaf, George and Co.
622 North Water Street
Milwaukee, Wisconsin 53202
414-276-2062

Barr Engineering Co.
6800 France Avenue South
Minneapolis, Minnesota 55435
612-920-0655

Bather-Ringrose-Wolsfeld-Jarvis-Gardner, Inc.
2829 University Avenue Southeast
Minneapolis, Minnesota 55414
612-379-7878

Bidstrup, Richard
Ridge Road
Harbor Springs, Michigan 49740
616-526-2031

Blair, George D.
720 South Durand
Jackson, Michigan 49203
517-782-9544

Commonwealth Assoc., Inc.
209 East Washington Avenue
Jackson, Michigan 49201
517-788-3573

Dolgaard, S.J.
1025 South Eighth Street
Brainerd, Minnesota 56401
218-829-6815

Drake, Douglas
P.O. Box 43A
3107 Main Street
Boyne Falls, Michigan 49713
616-549-2920

Dumke, William D.
Northwood Company
Brainerd, Minnesota 56401
218-829-0904

Ecological Services Research
312 West Genesee
Iron River, Michigan 49935
906-265-9035

Edward Steigerwaldt & Sons
Route 5
Tomahawk, Wisconsin 54487
715-453-3274

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*This list may not be comprehensive or up-to-date, nor does inclusion in this list constitute endorsement by the federal government.

APPENDIX B

LOCAL CONSULTING SOURCES

Michigan, Minnesota, and Wisconsin

Private

(Continued)

Environmental Collaborative
10304 94th Avenue North
Maple Grove, Minnesota 55369
612-425-3742

Ferrar, George
2026 Arrowhead Drive
Traverse City, Michigan 49684
616-946-5622

Forestry Associates
P.O. Box 392
Preston, Minnesota 55965
507-268-4466

Greentree Consultants, Inc.
P.O. Box 27125
Lansing, Michigan 48909
517-485-5783

Hays, Ronald M. & Associates
5857 Creek Valley Road
Edina, Minnesota 55435
612-941-3795

Keiser, Gerald E.
Box 358
Indian River, Michigan 49749
616-238-8444

Limnetics, Inc.
6132 West Fond du Lac Avenue
Milwaukee, Wisconsin 53218
414-461-9500

Locke, Edward
P.O. Box 488
Marquette, Michigan 49855
906-228-7960

McCraney, Robert
South Newberry Avenue
Box 426
Newberry, Michigan 49868
906-293-5138

Miller, Roswell K.
Woodland Road
Box 20
Houghton, Michigan 49931
906-482-0516

Moulton, John C. and Associates
1335 Elizabeth Street
Rhinelander, Wisconsin 54501
715-369-4789

Olson, Ralph H.
821 Willow Lane
Grand Rapids, Minnesota 55744
218-326-2534

Sainio, Eino
Box 105
Newberry, Michigan 49868
906-293-8601

Schweigert & Young, Inc.
2234 Intertown Road
Petoskey, Michigan 49770
616-347-2292

Stout, Bernard
Route 2
Morley, Michigan 49336
616-823-2184

Underbakke, Maynard
Fountain, Minnesota 55935
507-268-4466

APPENDIX B

LOCAL CONSULTING SOURCES

Michigan, Minnesota, and Wisconsin

Private

(Concluded)

Washburn, Robert D.
Str. Route Box 203E
County Road 550
Marquette, Michigan 49855
906-345-9905

Wilde, S.A. and Associates
1718 Hoyt Street
Madison, Wisconsin 53705
608-238-1653

Woodland Services, Inc.
Box 257
Moose Lake, Minnesota 55767
218-389-6142

Sources:

Association of Consulting Foresters. 1976. Membership Specialization Directory. Association of Consulting Foresters, Wake, VA.

> Lists consultants alphabetically by name of firm including detailed bibliographic information along with areas of specialization. A geographical breakdown by state is included also.

National Society of Professional Engineers. 1979. Directory of Engineers in Private Practice. Professional Engineers in Private Practice, Washington, D.C.

> Lists engineering firms alphabetically by state and area of specialization.

Society of American Foresters. 1978. Consulting Foresters: A Directory of consultants who are members of the Society of American Foresters. Society of American Foresters, Washington, D.C. 25 pp.

> Lists consultants alphabetically by name of firm with areas of specialization noted. There is also a geographical breakdown by state and province.

Wasserman, P., ed. 1979. Consultants and Consulting Organizations Directory, 4th ed. Gale Research Co., Detroit, MI.

> A reference guide to concerns and individuals engaged in consultation for business and industry. Includes a subject index of firms by location.

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APPENDIX C

STATE REGULATORY AGENCIES

Michigan Department of Natural Resources
Geological Survey Division
P.O. Box 30028
Lansing, Michigan 48909
517-373-1256

Minnesota Department of Natural Resources
Division of Minerals
Mineland Reclamation Section
Centennial Building
658 Cedar Street
St. Paul, Minnesota 55101
612-296-4807

Wisconsin Department of Natural Resources
Bureau of Solid Waste
Mine Reclamation Section
P.O. Box 7921
Madison, Wisconsin 53707
608-266-2111

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APPENDIX D

SOIL TESTING LABORATORIES[1]

Michigan, Minnesota and Wisconsin

Alpena Soil Testing Laboratory[3]
616 Ford Avenue
Alpena, Michigan 49707

Analytic & Biological Laboratories, Inc.
30754 Ford Road
Garden City, Michigan 48135
313-422-7474

Anderson Fertilizer Services, Inc.
2301 West Dewey Road
Owosso, Michigan 48867
517-723-5205

Dairyland Laboratory
Arcadia, Wisconsin 54612
608-323-3988

Detroit Testing Laboratory, Inc.
8720 Northend Avenue
Oak Park, Michigan 48237
313-398-2100

Walter H. Flood & Co., Inc.
7310 Garden Lane
Portage, Michigan 49081
616-327-7095

Lakehead Testing Laboratory,
P.O. Box 7168
Duluth, Minnesota 55807
218-628-2295

P.O. Box 666[2]
Buhl, Minnesota 55714
218-258-3373

Materials Testing Consultants, inc.
693 Plymouth Northeast
Grand Rapids, Minnesota 49505
616-456-5469

900 Patterson[2]
Bay City, Michigan 48706
517-893-3162

Michigan Testing Engineers, Inc.
24355 Capitol Avenue
Detroit, Michigan 48239
313-255-4200

1342 North Main Street[2]
Ann Arbor, Michigan 48104
313-994-3210

G-3309 West Pasadena[2]
Flint, Michigan 48504
313-732-8660

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[1] This list may not be comprehensive or up-to-date, nor does inclusion in this list constitute endorsement by the federal goverment.

[2] Branch laboratory of office.

[3] Telephone number unavailable.

APPENDIX D

SOIL TESTING LABORATORIES

Michigan, Minnesota and Wisconsin

(Continued)

2605 North Grand River Avenue[2]
Lansing, Michigan 48906
517-321-1324

Minnesota Valley Testing Laboratories
Center and German Streets
New Ulm, Minnesota 56073
507-354-8517

Northwest Testing Laboratory, Inc.
219 Turtle Street
Altoona, Wisconsin 54720
715-832-7418

Rock River Laboratory
Rt. 3, Box 332
Watertown, Wisconsin 53094
414-261-0446

Sohigro Service Co.
977 - 118th Avenue
Martin, Michigan 49070
616-781-2540

Soil and Forage Laboratory[3]
Marshfield Experiment Station
Marshfield, Wisconsin 54449

Soil and Plant Analysis Laboratory
University of Wisconsin
806 South Park Street
Madison, Wisconsin 53715
608-262-4364

Soil Exploration Company
(A sister corporation to Twin City Testing & Engineering Laboratory, Inc.)
662 Cromwell Avenue
St. Paul, Minnesota 55114
612-645-6446

Route 5 Box 18[2]
Mankato, Minnesota 56001
507-625-8211

3908 Commerce Court Southwest[2]
Rochester, Minnesota 55901
507-288-7060

705 Hickory Farm Lane[2]
Appleton, Wisconsin 54911
414-733-8711

P.O. Box 1183[2]
Eau Claire, Wisconsin 54701
715-832-0282

2710 Commerce Street[2]
LaCross, Wisconsin 54601
608-782-6110

5807½ Prairie Street[2]
Schofield, Wisconsin 54401
715-359-9463

Soil Testing Laboratory
Crop and Soil Science Department
Michigan State University
East Lansing, Michigan 48824
517-355-0210

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[2] Branch laboratory or office.

[3] Telephone number unavailable.

APPENDIX D

SOIL TESTING LABORATORIES

Michigan, Minnesota, and Wisconsin

(Concluded)

Soil Testing Laboratory
University of Minnesota
1529 Gortner Avenue
St. Paul, Minnesota 55108
612-373-1060

Soils Laboratory
Forestry Department
Michigan Technological University
Houghton, Michigan 49931
906-487-2433

Twin City Testing & Engineering Laboratory, Inc.
662 Cromwell Avenue
St. Paul, Minnesota 55114
612-645-3601

Wadena Dairy Products Laboratory[3]
4 Colfax Avenue Southeast
Wadena, Minnesota 56201

WDHIC - Bonduel
(Agricultural Records Cooperative - former name)
Bonduel, Wisconsin 54107
715-758-2265

Wilmar Testing Laboratory
Wilmar, Minnesota 56201
612-235-3915

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[3] Telephone number unavailable.

Note: Before submitting samples, customers should request information on current testing fees, sample information forms, instructions on collection and delivery of samples.

Sources

Agricultural Stabilization & Conservation Service approved laboratories for the three states (personal communication).

American Council of Independent Laboratories, Inc. 1980. Directory: A Guide to the Leading Independent Testing, Research and Inspection Laboratories of America. ACIL, Washington, D.C. 259 pp.

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APPENDIX E

SEED AND PLANTING STOCK SOURCES[1]

Michigan, Minnesota, and Wisconsin

Source	Wild Flower Seed	Native[2] Grass Seed	Native[2] Tree and Shrub Seed	Native[2] Trees and Shrubs	Misc. Native[2] Plant Material
Armin Trout's Evergreen Nursery Route 7, 2815 - 113th Avenue Allegan, Michigan 49010 616-673-2704				x	
Bailey Nurseries, Inc. 1325 Bailey Road St. Paul, Minnesota 55119 612-459-9744				x	
Chippewa Farms Greenhouse Route 1, Box 246 Brandon, Minnesota 56315 612-524-2244 (Containerized seedlings - mostly conifers)				x	
Dutch Mountain Nursery[3] 7984 North 48th Street R-1 Augusta, Michigan 49012				x	x

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[1] This list may not be comprehensive or up-to-date, nor does inclusion in this list constitute endorsement by the federal government.

[2] Many of these sources also have seed and planting stock that is considered non-native.

[3] Telephone number unavailable.

APPENDIX E

SEED AND PLANTING STOCK SOURCES

Michigan, Minnesota, and Wisconsin

(Continued)

Source	Wild Flower Seed	Native Grass Seed	Native Tree and Shrub Seed	Native Trees and Shrubs	Misc. Native Plant Material
Evergreen Nursery Co., Inc. Rt. 3, 5027 County Trunk TT Sturgeon Bay, Wisconsin 54235 414-743-4464				x	
Ferndale Nursery & Greenhouse Box 218 Askov, Minnesota 55704 612-838-3636 (Wildflowers and ferns)					x
High Meadow Farm Rt. 3, Box 3188 Mt. Horeb, Wisconsin 53572 (Company does not ship)				x	x
Howard's Christmas Farms and Nursery R.R. 2 Sparta, Wisconsin 54656 608-272-5431				x	

APPENDIX E

SEED AND PLANTING STOCK SOURCES

Michigan, Minnesota, and Wisconsin

(Continued)

Source	Wild Flower Seed	Native Grass Seed	Native Tree and Shrub Seed	Native Trees and Shrubs	Misc. Native Plant Material
Kester's Wild Game Food Nurseries, Inc. 4488 Highway 116 East P.O. Box V Omro, Wisconsin 54963 414-685-2929 (Native aquatic plants and seeds)				x	x
L.L. Olds Seed Company 2901 Packers Avenue P.O. Box 7790 Madison, Wisconsin 53707 608-249-9291	x				
Little Valley Farm[3] R.R. 1, Box 287 Richland Center, Wisconsin 53581	x				x
Michigreen Nursery 12531 North Cedar Drive Grand Haven, Michigan 49417 616-842-2674				x	

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[3] Telephone number unavailable.

APPENDIX E

SEED AND PLANTING STOCK SOURCES

Michigan, Minnesota, and Wisconsin

(Continued)

Source	Wild Flower Seed	Native Grass Seed	Native Tree and Shrub Seed	Native Trees and Shrubs	Misc. Native Plant Material
Needlefast Evergreens Rt. 2, Hansen Road Ludington, Michigan 49431 616-843-8524		x			
Nepco Lake Nursery (Nekoosa Papers, Inc.) Port Edwards, Wisconsin 54469 715-887-5301				x	
Northern Farm and Garden First Street & Minnesota Avenue Bemidji, Minnesota 56601 218-751-3350				x	
Orchid Gardens[3] 600 Splithand Road Grand Rapids, Minnesota 55744				x	x

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[3] Telephone number unavailable.

APPENDIX E

SEED AND PLANTING STOCK SOURCES

Michigan, Minnesota, and Wisconsin

(Continued)

Source	Wild Flower Seed	Native Grass Seed	Native Tree and Shrub Seed	Native Trees and Shrubs	Misc. Native Plant Material
Pinery, The Rt. 6, Box 973 River Road Mosinee, Wisconsin 54455 715-693-2428				x	
Prairie Associates[3] 6328 Piping Rock Road Madison, Wisconsin 53711	x	x			x
Prairie Nursery[3] Box 116 Westfield, Wisconsin 53964	x	x			x
Prairie Ridge Nursery[3] 9738 Overland Road, R.R.2 Mt. Horeb, Wisconsin 53572	x	x	x	x	x
S & R Seed Company R.R. 2 Cass Lake, Minnesota 56633 218-335-2363			x		

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[3] Telephone number unavailable.

APPENDIX E

SEED AND PLANTING STOCK SOURCES

Michigan, Minnesota, and Wisconsin

(Continued)

Source	Wild Flower Seed	Native Grass Seed	Native Tree and Shrub Seed	Native Trees and Shrubs	Misc. Native Plant Material
Sperka's Woodland Acres Nursery[3] Rt. 2 Crivitz, Wisconsin 54114	x				x
Strand Nursery Company[3] Rt. 2, Box 16A Osceola, Wisconsin 54020 (Hardy native ferns and wildflowers - dormant roots)					
Superior View Farm[3] Box 636 Bayfield, Wisconsin 54814 (Hardy perennials)					x
Vans Pines, Inc. R.R. 1 West Olive, Michigan 49460 616-399-1620			x	x	

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[3] Telephone number unavailable.

APPENDIX E

SEED AND PLANTING STOCK SOURCES

Michigan, Minnesota, and Wisconsin

(Continued)

Source	Wild Flower Seed	Native Grass Seed	Native Tree and Shrub Seed	Native Trees and Shrubs	Misc. Native Plant Material
Wavecrest Nurseries 2509 Lakeshore Drive, Rt. 2 Fennville, Michigan 49408 616-543-4175				x	
Weller Nurseries P.O. Box 1111 Holland, Michigan 49423 616-335-5854 (Wildflowers and hardy ferns)					x
Wildlife Nurseries P.O. Box 2724 Oshkosh, Wisconsin 54901 414-231-3780 (Aquatic plants)					x
Zelenka Evergreen Nursery, Inc. 16127 Winans Street Grand Haven, Michigan 49417 616-842-1367				x	

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[3] Telephone number unavailable.

APPENDIX E

SEED AND PLANTING STOCK SOURCES

Michigan, Minnesota, and Wisconsin

(Concluded)

Sources Used:

Soil Conservation Society of America. 1979. Sources of Native Seeds and Plants. Soil Conservation Society of America, Ankeny, IA. 20 pp.

U.S. Forest Service. 1979. Seed and Planting Stock Dealers: A Director of Dealers that Sell the More Common Forest and Shelterbelt Seeds and Plants. U.S. Government Printing Office, Washington, D.C. 22 pp.

Other Sources of Information on Plant Materials:

Sources of Plants and Related Supplies
American Association of Nurserymen, Inc.
230 Southern Building
Washington, D.C. 20005

Forest Tree Seed Orchards
(A directory of industry, state, and federal forest tree seed orchards in the United States)
U.S. Forest Service, U.S. Department of Agriculture
Washington, D.C. 20250

Nursery Source Guide
Brooklyn Botanic Gardens
1000 Washington Avenue
Brooklyn, New York 11225

Source of Planting Stock and Seed of Conservation Plants Used in the Northeast, 1978-1979
Soil Conservation Service, U.S. Department of Agriculture
Northeast Region Technical Service Center
1974 Sproul Road
Broomall, Pennsylvania 19008

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APPENDIX F

SELECTED WILDLIFE SPECIES REQUIREMENTS

WHITE-TAILED DEER

The white-tailed deer prefers woodlots with mast-producing hardwoods, numerous thickets, grassy openings, and permanent surface water.

Food -- White-tailed deer have a varied herbaceous diet. During the summer, deer consume leaves and twigs of aspen, maple, sumac, yew, dogwood, wintergreen, red-osier dogwood, and leatherleaf, to mention a few. Oak mast, when available, is popular in the fall. Their winter diet includes twigs and branches of white cedar, hemlock, sumac, mountain maple, red-osier dogwood, and wintergreen. Agricultural crops such as corn and soybeans are eaten when available.

Water -- One permanent water source per square mile is needed for suitable white-tailed deer habitat.

Cover -- Areas of dense woody vegetation are used for thermal and escape cover. In northern regions where snow depths exceed 20 inches for extended periods of time, deer normally seek shelter under dense coniferous cover where food supplies are available, normally white cedar, spruce, or tamarack swamps.

Interspersion -- Winter and early spring deer ranges are about 700 acres. Summer ranges for does and immature bucks are about 600 to 1,000 acres, while adult bucks have ranges of 3,600 acres. Range size varies depending upon existing habitat conditions. Ideal habitat would include water; a source of browse; dense, bushy, escape and thermal cover; and, in heavy snow regions, coniferous cover adjacent to woody browse.

APPENDIX F
SELECTED WILDLIFE SPECIES REQUIREMENTS
(Continued)

RUFFED GROUSE

The ruffed grouse, a game bird common in aspen/birch forests, prefers an interspersion of various age classes of aspen near alder bottomlands.

Food -- Ruffed grouse chicks feed almost exclusively on insects during the first two weeks of their life. Throughout the summer, their diet includes the fruits and leaves of various herbaceous plants. Adult birds feed almost exclusively on herbaceous plants. Winter foods include the buds, twigs, and catkins of hazel, aspen, and birch. When available, leaves of bunchberry, strawberry, and other broadleaf evergreen plants are also eaten.

Water -- Sufficient water is probably obtained from feeding on dew-covered plants.

Cover -- The ruffed grouse requires habitats with high brush densities which serve as protective cover from such natural predators as the goshawk, great horned owl, and red fox. The bird generally inhabits aspen/birch forests with dense understories of hazel. Mature male aspen trees are an essential component of the habitat in the north central states. Conifers in the canopy are detrimental to long-term grouse survival because they serve as protective cover for grouse predators.

Interspersion -- The size of their seasonal use area is generally 10 to 40 acres. Female grouse are more mobile than the males and utilize a spring nesting range, a summer brood range, and a winter range. Ruffed grouse require early successional stage forests with an interspersion of various age classes and some openings. Ideal habitats includes four age classes of aspen, 0-10, 11-20, 21-30, and 31-40+ years, in equal proportions per 10 acres. Small grassy and bushy openings provide open areas for dust-bathing and sunning.

APPENDIX F
SELECTED WILDLIFE SPECIES REQUIREMENTS
(Continued)

WOODCOCK

The American woodcock is an inhabitant of a mixture of open woodlands and grassy areas.

Food -- The woodcock's diet consists primarily of animal matter, of which 50 to 75 percent is earthworms. Other food includes beetles, flies, spiders, ants, caterpillars, and grasshoppers. Vegetable foods include the seeds of sedges, blackberries, raspberries, violet, and alder.

Water -- Woodcock depend on soft, moist earth for feeding and are found near moist thickets and stream bottoms. Free water probably need not be available because their food probably contains sufficient water.

Cover -- Woodcock prefer open woodland stands with trees 10 to 20 feet tall and 15 to 30 years old. A mixture of four to 30 percent woody vegetation and 40 to 50 percent herbaceous vegetation in scattered patches and clumps is desirable. These open, grassy areas, used in the spring courtship ritual, are called "singing grounds."

Interspersion -- The general cruising range of the woodcock is about 300 feet and includes woody and open areas.

APPENDIX F
SELECTED WILDLIFE SPECIES REQUIREMENTS
(Continued)

COYOTE

The coyote is a medium-sized carnivore frequenting woodland borders and brushy areas. This animal is also commonly called a brush-wolf.

Food -- About 98 percent of the coyote's diet is made up of animal matter, mostly mammals. Birds and other vertebrates make up about three percent of the total diet. Wild fruits are consumed from July through October, but these do not exceed more than five or six percent of the diet during that period. Common prey include cottontail rabbits, snowshoe hares, field mice, ground squirrels, voles, woodchucks, pocket gophers, and muskrats.

Water -- A source of free water is required daily.

Cover -- The coyote inhabits brushy fields and woodlands and is only rarely seen in open fields or grassy meadows. The coyote sometimes digs its own burrow but may also enlarge an abandoned woodchuck, badger, skunk, or fox burrow or may build a den within a rock crevice, at the base of a cliff, or under a stump. Burrow dens may have two or three entrances, may be 20 to 30 feet long, and are seldom more than three to four feet underground.

Interspersion -- A diversity of habitat types favorable to rabbits, hares, and mice is most beneficial to the coyote. An interspersion of woodland borders, brushy fields, cutover or burned second-growth forests, dry marshes, and prairies with scattered rows and thickets of brush are favorable coyote habitat.

APPENDIX F

SELECTED WILDLIFE SPECIES REQUIREMENTS

(Continued)

SHARP-TAILED GROUSE

The sharp-tailed grouse generally inhabits a blend of openings, low brush, and scattered thickets in early successional forests.

Food -- The sharp-tailed grouse is primarily a herbivorous feeder, consuming leaves and buds of a variety of plants. Winter foods include white birch and aspen buds, catkins, rosehips, willow and cherry buds, and twigs. During the summer, their food sources include fruit, flowers, buds, seeds or leaves of wild rose, yellow goatsbeard, prickly lettuce, poison ivy, hazel nut, clover, buckwheat, blackberry, bearberry, sheep sorrel, bog cranberry, dandelion, strawberry, cloves, fire cherry, raspberry, and hawthorn.

Water -- Water is probably not a restricting factor.

Cover -- The sharp-tailed grouse requires a mixture of grassy openings, dense brushy thickets, and patches of aspen and birch. The open areas are used as brood habitat in the summer. During the fall and winter, sharp tails begin congregating in blocks of 10 to 30 birds in open grassy areas and move into clumps of aspen and birch as snow begins to accumulate. Sharp tails will roost beneath the surface of the snow when conditions permit.

Interspersion -- The ideal distribution per square mile in Michigan, Minnesota, and Wisconsin would be about 6 percent (40 acres) of herbaceous cover consisting of low grass with scattered patches of heavier grass, willow, blueberry, or fern. This area would serve as the dancing ground and should be near the center of the section. Surrounding this area should be a tract of about 320 acres consisting of 80 percent dense grasses and 20 percent woody cover of pincherry, juneberry, or other shrubby species. Clumps of aspen/birch from .1 acre to two acres should be scattered throughout. Outside of the grass-shrub zone is a tract about 280 acres in size consisting of second-growth aspen/birch with 50 percent canopy closure interspersed with scattered clearings about 10 acres in size occupying about one-third of the area.

APPENDIX F

SELECTED WILDLIFE SPECIES REQUIREMENTS

(Continued)

RED FOX

The red fox inhabits fairly open areas such as old fields, grass and croplands, wet meadows, and small woodlots. Areas around streams are often used.

Food -- The red fox is omnivorous, generally consuming vegetable matter as readily as animal matter. Cottontail rabbits and mice form the staple diet. In summer and fall meadow voles may make up half of its food. Other food includes apples, berries, grass, corn, various insect species, small- and medium-sized birds, squirrels, woodchucks, muskrats, skunks, domestic poultry, and carrion.

Water -- A source of free water is required daily.

Cover -- Cover requirements for the red fox are very general. Dens used for rearing a litter of young fox kits are either dug by the female or enlarged from some other animal dens. Hollow trees and logs and cavities under buildings are also used as dens. Ground dens are generally in heavy cover such as fencerows, woodlot edges, and fallow fields. Dens are generally dug in well-drained, fine, sandy loams on slightly elevated knolls. Often the den is on a southern slope.

Interspersion -- The red fox does best in a maximum diversity of cover types. In southwestern Wisconsin, where an interspersion of woodlots, croplands, pasture, and stream bottoms occurs, the red fox does exceptionally well. Transition zones between vegetation types seem to be favored. Mowed or grazed land is used infrequently, and large, homogeneous tracts of a single cover type are generally avoided. The home range of the red fox depends on terrain, habitat complexity, and food supply but generally is between 640 to 1,200 acres.

MEADOW VOLE

The meadow vole is a small rodent that prefers moist areas with dense, grassy cover. Meadow voles serve as prey for hawks, owls, weasels, mink, striped skunk, badger, coyote, and fox. Vole populations will respond to grassland development and management practices.

Food -- The meadow vole's summer diet consists of fresh grass, sedges, and other herbaceous plant material. In the fall and winter, voles consume a variety of grain and weed seeds. Sometimes they will also eat the bark and roots of shrubs and small trees. A small amount of animal matter is included in their diet.

Water -- Specific water requirements were not identified in the literature. However, the meadow vole seems to prefer moist grassy areas.

Cover -- Moist areas vegetated by grasses and grasslike species are generally preferred meadow vole habitat. Herbaceous canopy cover of about 85 percent seems to provide optimum cover. Wooded areas are generally avoided. To provide safe travel, the vole constructs runways from available herbaceous vegetation.

Interspersion -- The meadow vole's home range is estimated to be 1/5 acre or less. All life requirements may be satisfied within a single vegetational type. The tremendous reproductive capacity of this species makes it useful as a prey species for various avian and mammalian predators. Providing extensive acreages of grasses and grasslike species is the best management practice.

APPENDIX F

SELECTED WILDLIFE SPECIES REQUIREMENTS

(Continued)

MUSKRAT

The muskrat inhabits shallow to deep marshes, streams, creeks, drainage ditches, and ponds.

Food -- The muskrat consumes a variety of aquatic plants. Included in its diet are broad-leaved cattail (a preferred food), hard stem and river bulrushes, duck potato, willow, sedges, arrowhead, spike rush, water bulrush, pickerel weed, and large-leaved pondweed. Animal matter, consumed occasionally, is a small part of the diet.

Water -- The muskrat requires areas with stable water levels with water depths not exceeding four feet.

Cover -- Suitable muskrat habitat contains dense stands of cattail, bulrush, and other emergent vegetation. The muskrat constructs a lodge of emergent vegetation for shelter or excavates a bank burrow in soils with less than 43 percent sand content. The main entrance is located below the water's surface.

Interspersion -- Adequate cover in the form of thickets and brushy areas is important as cover and for loafing sites especially during periods of excessively high or low water. Food must be available near cover during the winter months. Home range size is about six acres.

MALLARD

The mallard is a surface-feeding duck found in a variety of habitats wherever sufficient water is present to permit courtship and brood-rearing. Generally, it prefers wetlands less than five feet deep fringed with a variety of emergents.

Food -- The mallard feeds primarily on aquatic plants, their seeds, and to a lesser extent on aquatic organisms. Mallards will also consume cultivated grains such as wheat and barley when available. Aquatic plants include the seeds of wild millet, beaked sedge, reed canary grass, pondweed, spikerush, bulrush, rice cut-grass, coontail, marsh smartweed, wild rice, and bur reed. Other vegetation includes duckweed and leaves from various submergent aquatic plants.

Water -- Water is essential for both courtship and brood-rearing activities.

Cover -- Mallards require wetland areas for courtship and brood-rearing and grassy upland areas for nesting. Suitable nesting habitat consists of dense upland vegetation about 24 inches high preferably within one-fourth mile of a suitable wetland. In some locales, sweet clover is preferred nesting cover. For brood-rearing, mallards prefer potholes less than one acre in size. Suitable emergent vegetation to serve as protective cover includes cattail, bulrush, and other erect emergent plants.

Interspersion -- Ideal habitat includes grassy areas suitable for nesting within a few hundred yards of semi-permanent shallow marshes. A large permanent marsh of 80 acres or more should be present to provide for cover for the flightless, moulting adult drakes, for the broods during late summer dry periods, and also as migratory staging areas.

APPENDIX F
SELECTED WILDLIFE SPECIES REQUIREMENTS
(Concluded)

CANADA GOOSE

The Canada goose is a large gamebird and common migrant through the Upper Midwest. Aquatic vegetation comprises the bulk of its diet, and consequently water depth should not exceed 18 to 24 inches in feeding areas. After they are old enough to fly, Canada geese graze primarily on succulent green forage.

Food -- The Canada goose feeds primarily on plant material and is predominantly a grazer. The Canada goose does particularly well in areas where agricultural crops are grown near water. Favored foods include a variety of agricultural crops (wheat, rye, barley, oats, millet, corn, buckwheat, and soybeans), pasture grasses (timothy, red top, brome grass, bluegrass, orchard grass, and fescues) and other green vegetation (e.g., clovers, birdsfoot trefoil, and lespedeza). Natural foods include wild millet, smartweed seeds, cut-grasses, spike rushes, sedges, bulrush, foxtail, sago pondweed, and wigeongrass.

Water -- Water is essential for courtship and brood-rearing activities. Also, geese normally return to water around midday after feeding in open fields, presumably to roost and drink.

Cover -- Open water generally provides for the protective cover requirements of geese. Any water body over 10 acres in size in an area with a variety of agricultural crops has the potential to serve the needs of the goose.

Interspersion -- Food and water must be within easy flight distance of each other. Nesting generally occurs within 50 yards of water so suitable nesting habitat must be situated close to water. Characteristics of suitable habitat include gently sloping shorelines and abundant plant food in the form of pasture grasses or semi-aquatic plants.

APPENDIX G

PLANT SPECIES USEFUL IN WETLAND DEVELOPMENT

(by water depth)

Name	Planting Stock	Planting Rate/Ac.
DRY, MOIST, OR INTERMITTENTLY FLOODED AREAS		
Wild Duck Millet, *Echinochloa crus-galli*	Seed	20-25 lbs.
Giant Smartweed, *Polygonum pensylvanicum*	Seed	20 lbs.
Reed Canary Grass, *Phalaris arundinacea*	Seed	10-12 lbs.
MOIST SHORES TO 1 FOOT OF WATER		
Giant Bur Reed, *Sparganium eurycarpum*	Roots	1,000 roots
Three-Square Bulrush, *Scirpus Torreyi*	Roots	1,000 roots
Cattail, *Typha latifolia*	Roots	1,000 roots
Marsh Smartweed, *Polygonum muhlenbergii*	Roots	1,000 roots
Cord Grass, *Spartina alterniflora*	Roots	1,000 roots
1 TO 3 FEET OF WATER		
Wild Rice, *Zizania aquatica*	Seed	50 lbs
Pickerel Plant, *Pontederia cordata*	Roots	600 roots
Tuberous White Water Lily, *Nyphaea tuberosa*	Rootstock	750 lbs.
1½ TO 8 FEET OF WATER		
Wild Celery, *Vallisneria spiralis*	Roots (seed in fall)	1,000 roots or 30 lbs. seed
Sago Pond Weed, *Potamogeton pectinatus*	Tubers (seed in fall)	1,000 tubers or 30 lbs. seed
Wigeon Grass, *Ruppia maritima*	Plants	4 bushels
Coontail, *Ceratophyllum demersum*	Plants	6 bushels
Elodea, *Anacharis canadensis*	Plants	10 bushels

Source: Wild Life Nurseries, Oshkosh, Wisconsin

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APPENDIX H

SELECTED UPPER MIDWEST FISH SPECIES

Common	Scientific
	Trout
Lake trout	*Salvelinus namaycush* (Walbaum)
Rainbow trout	*Salmo gairdneri* Richardson
Brook trout	*Salvelinus fontinalis* (Mitchill)
Brown trout	*Salmo trutta* Linnaeus
Cisco (tullibee)	*Coregonus artedii* Lesueur
	Bass
Largemouth bass	*Micropterus salmoides* (Lacepede)
Smallmouth bass	*Micropterus dolomieui* Lacepede
	Pike
Northern pike	*Esox lucius* (Linnaeus)
Muskellunge	*Esox masquinongy* Mitchill
Tiger muskie	*E. lucius* x *E. masquinongy*
	Perch
Walleye	*Stizostedion vitreum vitreum* (Mitchill)
Sauger	*Stizostedion canadense* (Smith)
Yellow perch	*Perca flavescens* (Mitchill)
	Panfish
Longear sunfish	*Lepomis megalotis* (Rafinesque)
Green sunfish	*Lepomis cyanellus* Rafinesque
Pumpkinseed	*Lepomis gibbosus* (Linnaeus)
Bluegill	*Lepomis macrochirus* Rafinesque

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APPENDIX I

RECOMMENDED PLANT SPECIES

Common Name	Scientific Name
Grasses	
Annual rye	*Lolium multiflorum*
Canada bluegrass	*Poa compressa*
Colonial bentgrass	*Agrostis tenuis*
Crested wheatgrass	*Agropyron desertorum or cristatum*
Durar hard fescue	*Festuca ovina*
Garrison creeping foxtail	*Alopecurus arundinaceus*
Green needlegrass	*Stipa viridula*
Intermediate wheatgrass	*Agropyron intermedium*
Kentucky bluegrass	*Poa Pratensis*
Orchard grass	*Dactis glomerata*
Perennial ryegrass	*Lolium perenne*
Red fesuce	*Festuca rubra*
Redtop	*Agrostis alba*
Reed canary grass	*Phalaris arundinacea*
Slender wheatgrass	*Agropyron trachycaulum*
Smooth brome	*Bromis inermis*
Switch grass	*Panicum virgatum*
Tall fescue	*Festuca arundinacea*
Tall wheatgrass	*Agropyron elongatum*
Timothy	*Phleum pratense*
Western wheatgrass	*Agropyron smithii*

APPENDIX I
RECOMMENDED PLANT SPECIES
(Continued)

Legumes

Alfalfa	*Medicago sativa*
Alsike clover	*Trifolium hydridum*
Birdsfoot trefoil	*Lotus corniculatus*
Cicer milk vetch	*Astragalus cicer*
Crown vetch	*Coronvilla varia*
Ladino clover	*Trifolium repens forma lodigense*
Perennial pea	*Lathyrus latifolius*
Red clover	*Trifolium pratense*
Sweet clover	*Melilotus alba or officinalis*
Wagner flat pea	*Lathyrus sylvestris*
White Dutch clover	*Trifolium repens*

Shrubs

Alder	*Alnus spp.*
Arrowwood	*Viburnum dentatum*
Grey dogwood	*Cornus racemosa*
Hawthorne	*Crataegus spp.*
Hazelnut	*Corylus cornuta*
Highbush cranberry	*Viburnum trilobum*
Red-osier dogwood	*Cornus stolonifera*
Serviceberry	*Amelanchier spp.*
Siberian peashrub	*Caragana spp.*
Smooth sumac	*Rhus glabra*
Tartarian honeysuckle	*Lonicera tatarica*
Wild rose	*Rosa spp.*
Willow	*Salix spp.*
Woodvine	*Parthenocissus quinquefolia*

APPENDIX I
RECOMMENDED PLANT SPECIES
(Concluded)

Trees

Balsam fir	*Abies balsamea*
Balsam poplar	*Populus balsamifera*
Bigtooth aspen	*Populus grandidentata*
Black spruce	*Picea mariana*
Crabapple	*Malus spp.*
European larch	*Larix decidua*
Green ash	*Fraxinus pennsylvanica*
Hybrid poplar	*Populus spp.*
Jack pine	*Pinus banksiana*
Mountain ash	*Sorbus aucuparia*
Northern white cedar	*Thuja occidentalis*
Norway spruce	*Picea abies*
Paper birch	*Betula papyrifera*
Red maple	*Acer rubrum*
Red pine	*Pinus resinosa*
Russian olive	*Elaeagnus angustifolia*
Scotch pine	*Pinus sylvestris*
Sugar maple	*Acer saccharum*
Tamarack	*Larix laricina*
Trembling aspen	*Populus tremuloides*
White pine	*Pinus strobus*
White spruce	*Picea glauca*

Temporary Cover (Annuals)

Barley	*Hordeum vulgare*
Buckwheat	*Fagopyrum esculentum*
Millet Japanese	*Echinachloa furmentacea*
Oats	*Avena sativa*
Rye	*Secale cereale*
Wheat	*Triticum aestivum*

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